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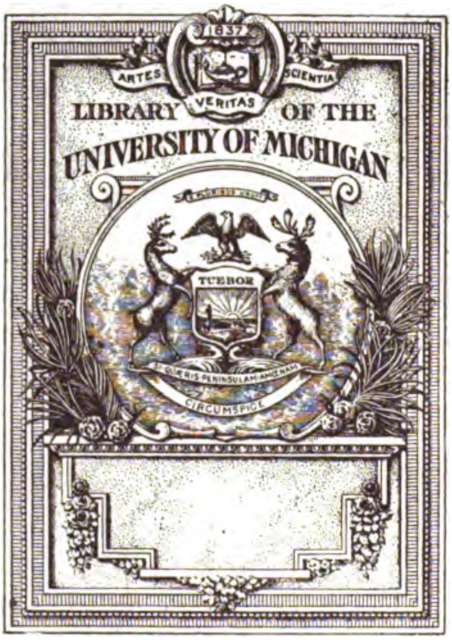
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Royal Meteorological Society.

Established 1850. Incorporated by Royal Charter, 1866.

Office:—30 GREAT GEORGE STREET, WESTMINSTER, S.W.

SESSION 1887.

ORDINARY MEETINGS AT 7 p.m.

Wednesday,	January* ...	19, 1887	Wednesday,	May	18, 1887
,,	February ...	16, ,,	,,	June	15, ,,
,,	March	16, ,,	,,	November ...	16, ,,
,,	April.........	20, ,,	,,	December ...	21, ,,

* Annual General Meeting.

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QUARTERLY JOURNAL

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VOL. XIII. JANUARY 1887. No. 61.

THE GALE OF OCTOBER 15th and 16th, 1886, OVER THE BRITISH ISLANDS.

BY CHARLES HARDING, F.R.MET.SOC.

[Read November 19th, 1886.]

THIS storm was one of exceptional severity in the west, south-west, and south of our Islands, but its principal violence was limited to these parts, although the force of a gale was attained by the wind over nearly the entire Kingdom. Besides the great violence of the storm in the districts named, there were peculiarities which occurred in connection with the disturbance which render it of especial interest; among the chief of these may be mentioned the erratic path of the storm system, the prolonged duration of the gale, the low reading of the barometer and the length of time that the mercury stood at an abnormally low value, as well as the deluge of rain which fell in the western parts of the country, and which occasioned unusually severe floods. The situation of the rain area with regard to the entire area of the storm was also exceptional, after the storm centre had come within the limits of our Islands.

The first indication of the probable approach of disturbed weather was shown on the morning of the 14th (Thursday), at which time the weather over nearly the whole of the British Islands was fine, and the wind was "light" to "moderate" from the North-west and West, the conditions being those commonly experienced in the rear of a disturbance. A depression had on the previous day been situated over the North Sea and was now skirting the coast of Norway, travelling in a northerly direction. In spite of these conditions the Meteorological Office in its Report for 8 a.m., 14th, gave the following remark:—"The barometer appears to be rising steadily in the west, and the wind there shows no sign of backing, but at Babbacombe and Jersey cirrus cloud is reported as moving fast from the northward. It is therefore not unlikely that a new depression is approaching our western coasts from the Atlantic." The distribution of atmospheric pressure over Europe was favourable to the arrival of depressions on our coast from off the Atlantic, the barometer readings being relatively low over our Islands, and high pressure areas being situated over Spain and the north of Norway—our Islands being, as it were, in a trough or valley between two crests or hills of high pressure. At 9 a.m. on the 14th the barometer at Valencia read 29·75 ins. and had ceased to rise, and between this and 10 a.m. it had fallen 0·018 in. After this the fall set in more rapidly, and by 2 p.m. the barometer was reading 29·59 ins., having fallen 0·16 in. The wind at 11 a.m. had backed to South-west-by-west, and by noon had further backed to South with heavy overcast weather. The indications given by the motion of the cirrus clouds and the Valencia observations were further confirmed at 2 p.m. by the barometer and the winds at Belmullet and Mullaghmore, and at 6 p.m. there was ample evidence that a deep depression was rapidly approaching Ireland. The barometer at Valencia was reading 29·28 ins., having fallen 0·52 in. in nine hours, and the wind had increased to a fresh gale from South-east, whilst at Roche's Point it was blowing a moderate gale from the South. The fall of the barometer had now extended to the western coasts of England and France, and in Great Britain the wind had backed generally except in the extreme north and east. In Spain, and over northern Russia, the areas of high barometer remained unaltered.

The Meteorological Office in its evening Report, reasoning on the 6 p.m. telegraphic information, said, "it is therefore probable that the centre of the approaching depression will advance directly over our Islands." The next Report issued by the Office proved the accuracy of this forecast, for at 8 a.m. on the 15th the centre of the disturbance had entered the area of the British Islands and was situated between Mullaghmore and Parsonstown (Fig. 1); the reading of the barometer at the centre of the storm being as low as 28·6 ins. The values of the respective high pressure areas over Spain and northern Russia had slightly increased. The strongest winds, which were 9 and 10 of Beaufort's scale (a strong and whole gale respectively), were at this time in the English Channel at some little distance from the centre of the disturbance, and it was now blowing a gale over the entire distance from the west coast of Ireland to Brussels and Skudesnaes in the east, and from Ardrossan to Corunna. The force of the wind was, however, very irregular. At some stations it was quite light without any sufficient reason, and certainly in opposition to the recognised rules of barometrical gradients. At Parsonstown the wind was South-west, force 2; at York East-south-east, 3; at Loughborough South-south-east, 3; and at Cambridge South, 1.

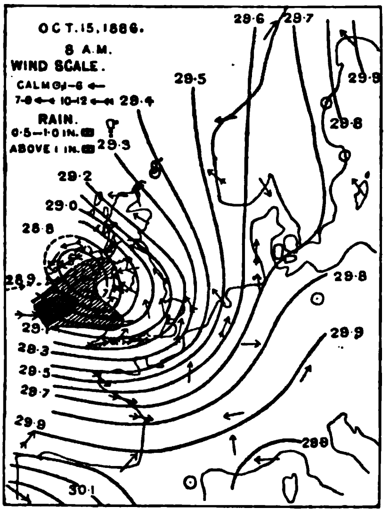

FIG. 1.

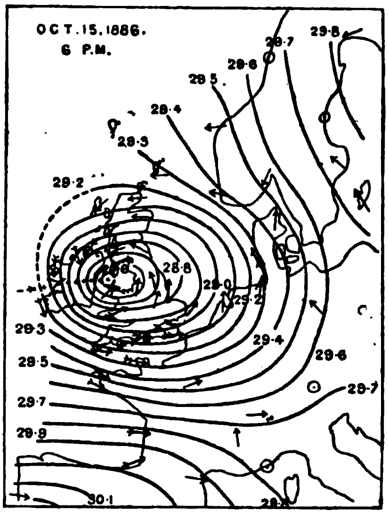

FIG. 2.

At 2 p.m. on the 15th the centre of the disturbance had moved nearly due east, and was just entering on its passage over the Irish Sea, being now situated slightly to the north and east of Dublin, where the lowest barometer reading was 28·53 ins. at 1 p.m., whilst at Holyhead the barometer was now 28·56 ins. The gale was at this time strongest in the south and west, and rain was falling over nearly the whole country.

At 6 p.m. on the 15th (Fig. 2) the disturbance was central over the Irish Sea, the barometer reading as low as 28·5 ins., and the readings over the whole of the British Islands were below 29·25 ins. The gale was strongest on the southern and western sides of the storm. The winds in the north-eastern quadrant were decidedly light, and the gradients were far less steep on the eastern side of the storm, the relative difference of steepness between the eastern and western sides being about 1 to 3. The high pressure areas were still holding over northern Europe and over Spain respectively, the former having decreased very little since the morning, whilst the latter had increased slightly. Rain continued to fall generally over the British Islands, as well as over central and western Europe. The anemograph traces at Holyhead show that the disturbance passed slightly to the north of that station between 8 and 9 p.m., the wind veering in the hour from West-south-west through North-west to North, its force showing a considerable falling off from 6 to 9 p.m.

At 8 a.m. on the 16th (Fig. 3) the disturbance had changed its course, and the centre was now situated over Wiltshire; the lowest value of the barometer remained unchanged, reading 28·55 ins. at Hurst Castle. A violent gale was still blowing over the English Channel and the Bay of Biscay, and strong gales were also reported from Ireland and from the west and south of England. The gradients were less steep than on the 15th, excepting perhaps in the north-west of France and the extreme west of Ireland. Rain was still falling generally over the British Islands, as well as over central, southern, and western Europe. The barometer over northern Europe remained unchanged, whilst in south-western Europe, over Spain, it had given way to the extent of about 0·2 in. The lightest winds were still to be found near the central area of the disturbance, and especially in the north-eastern segment.

At 2 p.m. on the 16th the centre of the storm was no longer over England but was situated about midway over the English Channel, between the Isle of Wight and Dieppe, and the system was apparently travelling direct for Paris; the barometer at the centre still continued about as low as before, and the gradients were still very steep in the south-west quadrant of the storm. The winds over the United Kingdom were moderating except at some few stations in the west and south-west, but they were still blowing with hurricane force on the west coast of France.

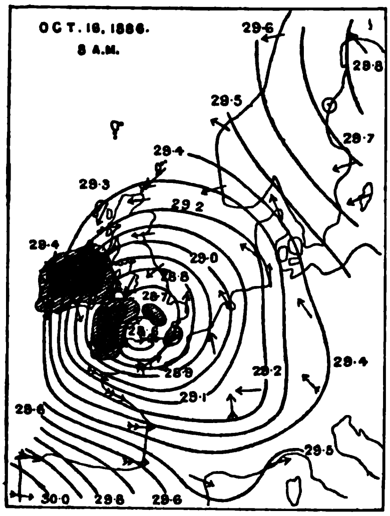

Fig. 3.

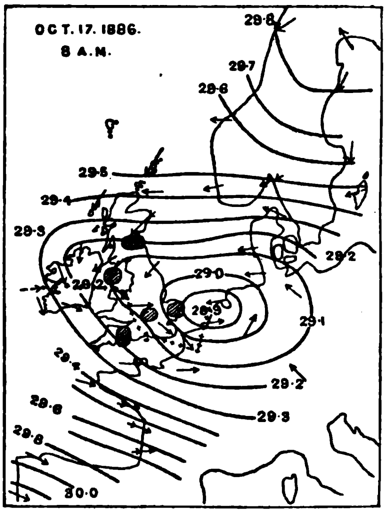

Fig. 4.

At 6 p.m. on the 16th the central area continued to travel south-eastward, and was near St. Valery on the coast of France. The lowest barometer was 28·77 ins. at Cape Gris Nez, and the gradients were generally less steep; they were, however, steepest in the south-west, and a perfect hurricane was reported at Rochefort and Biarritz, whilst gale force was still prevailing at one or two places in England. The lightest forces continued in the north-east quadrant of the storm. The high pressure areas in the north and south of Europe remained almost unchanged.

At 8 a.m. on the 17th (see Fig. 4) the disturbance had again changed the direction of its path, and it must have commenced to do so early on the preceding evening, as it was now situated over Holland. The barometer at the centre was rising somewhat, the lowest reading being 28·83 ins. at the Helder. The force of the wind was subsiding, and the gradients were everywhere less steep. Subsequent to this the disturbance remained stationary over Holland and gradually died out.

To render the information as complete as possible, and to avoid any discrepancy which might creep in from eye observations of the barometer or estimated observations of wind-force, a collection has been made of all the self-registering records available in the United Kingdom; in this way the automatic records have been obtained from twenty-two stations. The exact epochs of the principal changes are given for these in Table I.

TABLE I.—OBSERVATIONS BY SELF-RECORDING BAROMETERS.

Station.	Fall commenced.			First Minimum.			Rose to	Second Minimum.			Hours belw 29 Ins.
	Day.	Hour.	Reading.	Day.	Hour.	Reading.		Day.	Hour.	Reading.	
			Ins.			Ins.	Ins.			Ins.	
Valencia	14	9 a.m.	29·75	15	1 a.m.	28·77	29·24	16	1 a.m.	29·22	12
Parsonstown ..	14	Noon	29·69	15	7 a.m.	28·60	29·02	15	Midt.	28·93	30
Kilkenny	14	10 a.m.	..	15	9 a.m.	..	..	15	Midt.	..	..
Scilly	14	11 a.m.	29·82	15	3–7 a.m.	29·18	29·24	16	6 a.m.	28·94	7
Stornoway	14	7 p.m.	29·43	15	4 p.m.	29·15	..	..	..	..	0
Glasgow	14	5 p.m.	29·54	15	7 p.m.	28·76	..	..	..	..	23
Aberdeen	14	6 p.m.	29·52	15	Midt.	28·97	..	..	..	..	10
Falmouth	14	Noon	29·87	15	7 a.m.	29·15	29·22	16	6 a.m.	28·81	10
Babbacombe	14	1 p.m.	29·79	15	3 p.m.	29·07	29·10	16	6 a.m.	28·66	16
Liverpool	14	4 p.m.	29·67	16	1 a.m.	28·51	..	..	..	..	35
Newton-Reigny	14	6 p.m.	29·61	16	1 a.m.	28·62	..	..	..	..	30
Stonyhurst	14	5 p.m.	29·68	16	1 a.m.	28·58	..	..	..	..	32
Cheadle	14	7 p.m.	..	16	6 a.m.	..	..	..	..	..	34
Buxton	14	4 p.m.	29·65	..	..	?28·65	..	..	..	..	34
Oxford	14	5 p.m.	29·74	16	7 a.m.	28·60	..	..	..	..	33
Worksop	14	6 p.m.	29·67	16	3 a.m.	28·61	..	..	..	..	33
Bedford	14	6 p.m.	29·72	16	7 a.m.	28·62	..	..	..	..	35
Berkhamsted ..	14	9 p.m.	29·71	16	9 a.m.	28·65	..	..	..	..	33
Wallington	14	7 p.m.	29·74	16	9 a.m.	28·63	..	..	..	..	33
Kew	14	6 p.m.	29·75	16	9 a.m.	28·64	..	..	..	..	32
Greenwich	14	6 p.m.	29·72	16	10 a.m.	28·66	..	..	..	..	40
Geldeston	14	7 p.m.	29·71	15	7 a.m.	28·75	..	..	..	..	50

From this Table it is seen that the first fall of the barometer set in at Valencia at 9 a.m. on the 14th, and the next of the self-recording stations showing the fall was Kilkenny, where it commenced at 10 a.m. At Scilly the fall commenced at 11 a.m., and at Falmouth at noon; the change, however, rapidly extended eastwards over the country; and in London and the neighbourhood the barometer commenced to fall at about 6 p.m.

The time of occurrence of the lowest barometer is far more irregular, and necessarily varies considerably with the relative position of the station with regard to the centre of the disturbance. At the western stations two separate and distinct minima are shown. At Valencia these were respectively 28·77 ins. at 1 a.m. on the 15th, and after a slight rise a second minimum of 29·22 ins. was recorded at 1 a.m. on the 16th. At Scilly the first minimum was 29·18 ins., the barometer remaining stationary at this point from 3 to 7 a.m. on the 15th, when after a slight recovery the barometer again fell till

6 a.m. on the 16th, when 28·94 ins. was recorded. Falmouth also experienced a very similar change of pressure—the first minimum was 29·15 ins. at 7 a.m. on the 15th, the second 28·81 ins. at 6 a.m. on the 16th. There is, however, no trace of a double minimum at the northern, central, or eastern stations. At Kew the lowest barometer reading was not reached till 9 a.m. on the 16th, and at Greenwich it was one hour later. The absolutely lowest reading of the barometer recorded during the gale was 28·51 ins. at Liverpool. The rate of the fall of the barometer was not excessive; at Valencia it was very slightly in excess of 0·1 in. per hour, when falling at its most rapid rate on the evening of the 14th. The most remarkable feature of the gale, as far as the action of the barometer was concerned, was probably the great length of time that the mercury remained at a low level. At Geldeston, not far from Lowestoft, the barometer was below 29·0 ins. for 50 hours, from 1 p.m. on the 15th to 8 p.m. on the 17th, and at Greenwich it was below 29·0 ins. for 40 hours.

Similar points of interest, obtained from the anemometrical records, are given for the wind in Table II.

TABLE II.—WIND OBSERVATIONS BY ANEMOGRAPHS.

Station.	Backed to			Maximum.				No. of hours above 30 miles.
	Day.	Hour.	Direction.	Day.	Hour.	Direction.	Velocity.	
							Miles.	
Valencia	14	11 a.m.	SWbW	15	8–10 a.m.	W WbW	58	50
Armagh	14	8 a.m.	WSW	15	4 a.m.	E	21	0
Glasgow	14	4 p m.	WSW	15	Noon	ENE	34	2
Aberdeen	15	6 a.m.	SE	15	7 and 9 p.m.	EbN	45	20
Scilly	14	1 p.m.	WSW	16	6 a.m.	NWbW	78	61
Falmouth	14	3 p.m.	SW	15 16	9 a.m. 6 a.m.	WSW WbN	59 55	52
Holyhead	14	3 p.m.	WSW	16	9 p.m.	NWbN	62	40
Babbacombe	..	..	..	..	..	..	45	25
Fleetwood	14	7 p.m.	SSW	16	11 a.m.	N	42	16
Liverpool	14	6 p.m.	SbW	15	3 a.m.	EbS	38	5
Rousdon	..	..	..	15	5 p.m.	WbN	59	50
Stonyhurst	14	9 p.m.	SWbS	15	6 a.m.	SEbE	20	0
Alnwick Castle	14	10 p.m.	SSW	15	Noon	ESE	36	5
North Shields	14	10 p.m.	SW	15	10 a.m.	SE	56	11
Oxford	14	6 p.m.	WSW	15	8 and 9 p.m.	WSW SWbW	40	15
Berkhamsted	14	9 p.m.	SW	15	5 a.m.	SE	26	0
Kew	14	11 p.m.	SbW	15	1 p.m.	SWbS	32	3
Greenwich	14	4 p.m. 10 p.m.	WSW S	15	10 p.m.	SW	40	12

This Table shows that the first backing of the wind occurred in Ireland shortly before noon on the 14th, and was fairly coincident with the first fall of the barometer. It also confirms what is well shown on the weather charts which illustrate this paper, that the strongest force of the gale was experienced in the south-west and west. There was a double minimum in the wind-force at the western stations corresponding to the double minimum of the barometer.

The absolutely highest velocity of the wind during the gale was 78 miles in the hour from North-west-by-north, registered at Scilly at 6 a.m. on the 16th, and at the same station 78 miles was registered at 2 p.m, on the 15th. Holyhead had the next highest hourly velocity, which was 62 miles from North-west-by-north at 9 p.m. on the 16th. At Falmouth and Rousdon (Lyme Regis) the velocity reached 59 miles in the hour. At Valencia it was 58 miles, and at North Shields 56 miles. In several parts of the country no exceptionally strong forces were recorded. At Kew the maximum hourly velocity was 32 miles, at Berkhamsted only 26 miles were registered in the hour, whilst at Armagh the maximum rate was 21 miles, and at Stonyhurst 20 miles. Next to the extreme violence of the storm in the south-west and west the special feature of interest was the prolonged duration of the gale. At Scilly the velocity was above 30 miles an hour for sixty-one hours, from 7 p.m. on the 14th to 8 a.m. on the 17th, it was above 40 miles an hour for forty-eight hours from midnight on the 14th to midnight on the 16th, above 50 miles for thirty-six hours, and above 60 miles for nineteen hours. At Falmouth it was above 30 miles an hour for fifty-two hours, at Valencia and Rousdon for fifty hours, and at Holyhead for forty hours.

The gale was peculiarly gusty, the squalls being characterised as 'violent' in many parts of the country, but actual records of the force of the squalls have been obtained from Greenwich and Liverpool only. At Greenwich the maximum pressure was 16·5 lbs. on the square foot at 8h. 30m. p.m. on the 15th, and at Liverpool it was 18·5 lbs. at 3h. 12m. a.m. on the 15th.

These pressures expressed in hourly rates are for Greenwich 57 miles, and for Liverpool 61 miles. The actual maximum rates at these stations were 40 miles at Greenwich and 38 miles at Liverpool, and assuming that the maximum force in the squalls at Scilly varied in the same ratio as the mean obtained from the results at Greenwich and Liverpool, we obtain 118 miles as the maximum force at Scilly, expressed in hourly rate, which is equivalent to 69·6 lbs. on the square foot.

The double minima of the barometer and the double maxima of wind force observed at the western stations, were doubtless intimately associated with the irregular course followed by the storm when within the area of our Islands. The track is shown in the charts by the line formed of crosses. When first striking our coasts near Galway Bay, at about 1 a.m. on the 15th, the storm was travelling about east-north-east, but after reaching the centre of Ireland, at 8 a.m. on the 15th, it travelled due east, and continued this course over the Irish Sea; its rate of travel at this time was very slow, and it would appear that the whole storm area came to a standstill for some hours. The average rate at which it crossed the Irish Sea was about 7 or 8 miles an hour, the centre passing very slightly to the north of Holyhead at about

9 p.m. on the 15th, after which the storm took a south-easterly course, and at 8 a.m. on the 16th was central over Wiltshire. The central area of the disturbance left the English coast at about noon on the 16th, and crossed the English Channel, the path becoming more easterly again. At 6 p.m. on the 16th the centre was close to St. Valery, after which it travelled to the north-eastward, and at 8 a.m. on the 17th was over Holland, where, as before stated, it died out. In all, the centre of the storm remained over the British Islands for about thirty-five hours, the system having travelled about 500 miles. The primary cause of the irregular course is probably due to the area of high barometer over northern Europe, and as this did not give way the storm area could not maintain its original direction to the north-eastward, it being a well-established fact that storms in our latitudes rarely skirt the southern edge of an area of high barometer, keeping, by preference, such high pressure areas on their eastern margin.

It seems, however, not improbable that there was a second cause acting to change the path of the storm after it had entered the British Islands. It will be noticed, that the heaviest rain which accompanied the storm fell in the western and south-western districts; this was especially so with the torrents of rain which fell between 8 a.m. on the 15th and 8 a.m. on the 16th (*see* shaded areas on Fig. 3 for the 16th, 8 a.m.). Theory demands that the principal rain area should be in the front or advancing segment of the storm, and although this theory is far from being borne out at times, it is only reasonable to expect that this rapid condensation, which was going on to a far greater extent in the rear of the storm than in its advance—should exercise an attraction in the direction of the locality where the heaviest rain was falling, the falls being nearly everywhere below 0·5 in. to the eastward of its path, whilst falls of 1·5 in. and 2 ins. were common to the westward or in its rear.

The largest amounts of rain recorded during the gale were—

from 14th, 8 a.m. to 15th, 8 a.m.

	In.		In.		In.
Dromore Castle, near Kenmare,	1·28	Roche's Point,	1·26	Carmarthen,	1·02

from 15th, 8 a.m. to 16th, 8 a.m.

	Ins.		In.
Aberystwith (Cwmsymlog)	3·88	Armagh	1·90
Castle Malgwyn (Cardigan)	2·75	Belmullet...	1·74
Batworthy (Devon) ...	2·53	Dublin	1·56
Llechryd (Cardigan) ...	2·49	Okehampton (Devon) ...	1·53
Markree...	2·14	Brookeborough (Fermanagh)	1·50
Balbriggan	2·08	Southmolton (Devon) ...	1·50
Londonderry	1·98		

from 16th, 8 a.m. to 17th, 8 a.m.

	In.		In.		In.
Stornoway ...	1·23	Dawlish ...	1·28	Exeter ...	1·02

The following facts will give some idea of the nature of the floods caused by the heavy rains :—

ARMAGH.—Parts of the town were flooded, and fields of grain in the district were much injured.

BELFAST.—A great deal of damage was done to the grain, a very large quantity of which was still in the fields in the north of Ireland. The loss of agricultural produce was very extensive. In several parts of Ulster the railway traffic was suspended, but only for a short period.

DUBLIN.—The amount of damage done by the storm was enormous. All the rivers were in high flood, and low-lying lands were submerged.

ARKLOW, CO. WICKLOW.—The river rose to an unprecedented flood height. A derelict hulk was swept from its moorings and carried away about twenty-three fishing smacks, only five of which were afterwards recovered. The total damage was estimated at about £8,000 or £9,000.

CARDIGANSHIRE.—Disastrous floods occurred in several parts of the country. At Aberystwith, in many parts of the town itself the water was from 5 ft. to 6 ft. deep, the inhabitants being confined to their upper rooms, and obtaining their food by the aid of boats. The Trefechan and Penybont bridges over the Rheidol were swept away, and communication with the southern portion of Cardiganshire was stopped. The lines of railway near Borth, as well as between Penmaenpool and Dolgelly (Merioneth), were rendered useless for traffic through the flooding of the rivers Lerry and Mawddach. In the village of Llechryd a number of houses were seriously submerged, some of the inhabitants having to be taken out of their upper story windows in coracles. The bridge was several feet under water. The Aeron was swollen to proportions unequalled within the memory of the oldest inhabitants. All the wooden bridges were washed away.

CARMARTHEN.—At Lanybyther the whole valley presented one vast sheet of water. The vale of Towy was one vast lake along the river course.

HEREFORD.—The Wye rose on the 17th until it was nearly 15 ft. above its summer level, and a vast extent of the country was flooded.

The following are a few brief notes showing other damage done by the storm:—

SCILLY ISLANDS.—The gale was terrific. All vegetation, even in the most sheltered places, was destroyed, including the whole of the chrysanthemum crop. One of the crew of the Seven Stones Lightship, who has been twenty years on board, stated that he had never seen heavier breakers.

ILFRACOMBE.—The Capstone Parade was inundated. The Hotel Baths, recently erected at an immense expense, were greatly damaged, the glass roof being washed away.

SWANSEA.—Great damage was done to property. Chimney-stacks were blown down, roofs damaged, and telegraph wires blown away.

BRIGHTON.—The damage was immense. At the east end of the town the scene was stated to be one of complete devastation. The greatest damage to the shore was confined to the part between the Grand Hotel and the Hove sea wall.

Observations have been obtained from the principal ocean steamers which were in the North Atlantic for a few days prior to the storm reaching our Islands. These tend to show that the disturbance originated about 250 miles to the south-east of Newfoundland on the 12th. The weather in the Atlantic had previously been very stormy, and it appears that the gale in question was at first secondary to a larger disturbance. Its full force was experienced by several vessels on the 13th, its centre at noon on that day being in about 45° N and 42° W. Vessels on the eastern side of the Atlantic also experienced the storm on the 14th, and they confirm what was a special feature of the gale when over these Islands, that the winds in the rear segment were by far the most violent. When the first indication of approaching bad weather was shown by the barometer and wind at our western outposts, the centre of the storm was about 500 miles to the west-south-west of the Irish coast, and the system was advancing at the rate of nearly 50 miles an hour.

The *ss. Ocean King* was outward bound. She experienced the first fall of the barometer prior to the gale at 6 a.m. on the 14th in 51°10′ N and 13°10′ W, and the wind backed from West-by-north to West-south-west. From 8 a.m. to noon the barometer fell 0·37 in., and the wind had further backed to South and was strong—the position of ship at noon being 51°21′ N and 14°24′ W. At 2 p.m. the wind was blowing a moderate gale, and by 4 p.m. the barometer had further fallen 0·53 in. (in 4 hours) and was now reading 28·80 ins. (corrected). At 5 p.m. in 51°15′ N and 15°15′ W the barometer was at its lowest, 28·67 ins., and the wind had veered to South-west. At 6 p.m. the barometer was perceptibly rising, the centre of the storm having passed slightly to the north of the vessel, and from this time the gale increased in strength. At 8 p.m. the wind had further veered to West and was blowing a whole gale. At 10 p.m. and midnight it was blowing a hurricane from West with a mountainous sea, and the steering gear was carried away. The vessel got to the westward of the gale by noon on the 15th in 50°34′ N and 14°47′ W.

The Cunard *ss. Etruria*, homeward bound from New York, experienced the first fall of the barometer (0·07 in.) for the storm between 8 a.m. and noon on the 12th, the ship at noon being in 44°50′ N and 48°50′ W. The wind was East-north-east moderate, but it afterwards backed to East-south-east. The barometer continued to fall and the wind remained South-east until after 4 p.m. on the 13th, at 8 a.m. it had increased to the force of a moderate gale. The ship's position at noon was 47°36′ N and 39°38′ W. The lowest reading of the barometer, 28·65 ins., was recorded at 10 p.m.—the ship being in 48° N and 36° W,—and at about this time the wind shifted from East-south-east to North-north-east as the centre of the storm passed to the south of the vessel. A strong gale was experienced till nearly noon on the following day, the 14th, when the vessel was in 49°9′ N and 30°25′ W, the barometer reading 29·67 ins.

The Cunard *ss. Umbria* was outward bound, and consequently going in an opposite direction to the *Etruria*. Her first indication of the storm was a fall of 0·25 in. in the barometer between 8 a.m. and noon on the 13th, the ship's position at noon was 48°51′ N and 36°14′ W. The centre of the storm also passed to the south of this ship. She experienced the lowest barometer, 28·95 ins., and shift of wind from East-south-east to North-north-east at 6 p.m. on the 13th, in 48° N and 38° W; in all the gale only lasted about six hours, but this vessel was meeting the storm and steaming through it at the rate of about 18 knots an hour. The *Etruria* was travelling to the eastward with the storm, but it was rapidly outstripping her, although she was steaming at the rate of about 18 knots an hour.

The White Star *ss. Adriatic* was homeward bound from New York. This vessel experienced the backing of the wind and the first fall of the barometer for the gale in 50° N and 34° W during the night of 12th to 13th. The wind, however, did not reach gale force till the early morning of the 14th, when the ship was in 51° N and 25° W. The centre of the storm passed a short distance to the north of the vessel at noon (ship's position 51°10′ N and 20°40′ W), when the barometer was 28·65 ins. and the wind subsided to the force of a moderate gale from about 8 a.m. to 4 p.m. The gale lasted throughout the 14th and 15th, and the strongest blow was from the North-west in the rear of the storm-centre on the night of the 14th-15th, when force 11 ("a storm") of Beaufort's scale was recorded in the Meteorological Log, and the captain remarks on the occurrence of violent squalls at frequent intervals. The ship arrived at Queenstown at 10 p.m. on the 15th.

The following extract confirms the shore observations:—

EXTRACT FROM LOG KEPT FOR THE METEOROLOGICAL OFFICE ON BOARD H.M. CABLE STEAMER *Monarch*, CAPTAIN R. DRAPER, IN PENZANCE ROADS.

Date.	Time.	Wind.		Barometer.	Weather.	Date.	Time.	Wind.		Barometer.	Weather.
		Direction.	Force.					Direction.	Force.		
				Ins.						Ins.	
14	Noon	WbS	4	29·850	bc	15	Midt.	W	7	29·102	bc
,,	4 p.m.	SSW	4	29·779	c	16	4 a.m.	WbN	8	28·931	cor^4
,,	8 p.m.	S	4	29·607	cd^8	,,	6.30 a.m.	WNW	10	28·857	..
,,	Midt.	SWbS	7	29·313	cd^8	,,	8 a.m.	NWbW	11	28·913	cor^4
15	4 a.m.	SWbS	8	29·163	oqd^2	,,	Noon	NWbN	7	29·068	bcr^2
,,	8 a.m.	WbS	8	29·166	ocq p	,,	4 p.m.	NNW	7	29·014	cq
,,	Noon	WbS	8	29·206	bc	,,	8 p.m.	NW	9	29·330	cg
,,	4 p.m.	W	10	29·212	gc qp	17	Midt.	NW	8	29·394	c
,,	8 p.m.	W	9	29·178	bcq	,,	4 a.m.	WNW	6	29·331	c

14th, 11 p.m. Wind gradually hauling round to SWbS. 15th, 4–8 a.m. Frequent squalls; Noon. Wind very puffy; 4–8 p.m. Frequent squalls. 16th, 2 a.m. Frequent squalls of a few minutes' duration, force 9; 6.30 a.m. Lowest point reached by the Barometer; 8 a.m. Frequent squalls of a few minutes' duration, and of hurricane force. The wind force is by Beaufort's scale 0 — 12, and the weather by Beaufort's Notation. The small figures in the weather column show the hours of rainfall.

The whole history of the gale affords about as satisfactory an instance as could well be wished of the "birth, life, and death of a storm." The fact that no warning of the existence of this gale near the American coasts was given either in the ship reports from New York forwarded to the Meteorological Office or by the Weather Bureau of the *New York Herald*, tends to show that it did not exist as a gale sufficiently near to the American coast to admit of warning being transmitted, and an examination of the United States Signal Service Weather charts shows that the disturbance did not come from the American Continent.

A most terrific sea was experienced on our western coasts and in the English Channel, and a list, kindly furnished through Captain Hozier, the Secretary of Lloyd's, shows the number of vessels to which casualties occurred on the British coasts during the gale; these disasters tell their own tale of the violence of the storm and are given in Table III.

During the gale the life boats of the Royal National Life Boat Institution were launched fourteen times, and were instrumental in saving 86 lives.

In conclusion I have to thank the Meteorological Council for allowing me

TABLE III.

NUMBER OF VESSELS TO WHICH CASUALTIES OCCURRED DURING THE GALE OF OCTOBER 15TH AND 16TH ON THE BRITISH COASTS, AS REPORTED ON LLOYD'S LISTS.

	Sailing.	Steam.	Total.
Abandoned	5	1	6
Foundered[1]	5	1	6
Stranded	42	2	44
Dismasted	7	1	8
Other causes of damage	67	27	94
Total	126	32	158

[1] There were doubtless other vessels foundered during the gale, the names of which are not yet known.

free use of the records in their office, and I have to acknowledge the ready assistance afforded by many who have contributed data, and to Mr. Marriott for the kindly manner in which he has undertaken, with the sanction of the Council, the drawing of the large diagrams used for illustrating this paper as well as for other assistance.

DISCUSSION.

Surg.-Maj. **BLACK** said that he was staying at Brighton at the time of the occurrence of this gale, and the stormy sea at high-tide was a grand sight, and well worth travelling to Brighton to see it bursting over the embankments. It was very satisfactory that the Meteorological Office authorities had been able to forecast the approach of this storm to this country from the West.

Mr. **CHATTERTON** said he was informed that between 5 and 6 p.m. on October 15th the Sevenstones Light-ship was struck by a terrific sea, and it was necessary to remove her for repairs, placing on the station another light-ship. Almost at the same time the keeper of the Bishop Rock Light-house reported a similarly heavy sea. It was estimated that the green water reached a point 50 feet above high-water mark, while the spray was dashed to a height of 180 feet. Mr. Harding's Table showed the maximum velocity of the wind to have been 78 miles per hour at Scilly, but in the squalls, say for a minute, or even five minutes, the velocity must have been much greater.

Captain **TOYNBEE** inquired of Mr. Chatterton if there was only one very heavy sea experienced at the Sevenstones Light-vessel and at the Bishop Rock Light-house; he said that a similar single very heavy sea had been reported by Captain Moss in his paper on the Storm of June 3rd, 1885, in the Gulf of Aden,[1] and it was Captain Moss's opinion that the sea was not produced by the gale. Captain Toynbee also asked Mr. Chatterton if it was possible that the time of tide had anything to do with the high sea in question.

Mr. **CHATTERTON** said he had been informed that it was a most extraordinary wave, and that it had only occurred once.

Mr. **CURTIS** remarked with reference to the velocity of 78 miles per hour, reported as the maximum force of the wind at Scilly, that it ought to be borne in mind that the instrument at Scilly had smaller arms and cups than the standard pattern anemometer used at other observatories, and therefore a higher factor must be applied to its indications before they could be fairly compared with those of the standard type. At present the factor 3 is used for both classes of instruments, and therefore the velocities indicated by the Scilly instrument are always less than they ought to be relatively to those recorded at, say, Falmouth or Valencia.

Mr. **BALDWIN LATHAM** stated that with regard to the excessive rainfall which occurred in the storm on October 15th, Mr. Richard Hassard, M.Inst.C.E., the engineer of the Rathmines Waterworks, had informed him that in nineteen hours 3¼ ins. of rain had fallen at an elevation of 800 feet above sea-level in the drainage area of these works. The drainage area rose to 2,700 feet above sea-level. The actual quantity observed to flow off the ground in this storm was about 22 cubic feet per minute per acre of drainage area. It was one of the largest flows off the ground that had been observed.

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[1] *Quarterly Journal*, Vol. XII. p. 175.

Mr. **Scott** complimented Mr. Harding on the degree of completeness to which he had brought the account of the storm in the short time which had elapsed since he was requested to take up the investigation. He said that there was one feature of the storm which was remarkable. Dr. van Bebber in his recent work had stated that as a general rule the rate of advance of a storm bore some relation to its violence. This materially increased the difficulty of giving timely warning of severe storms. In the case of the storm now under notice, it would, however, be seen that though it was extremely violent it moved very slowly.

Mr. **Harries** said that from the diagrams it was evident that the barometric gradient was not of itself sufficient to account for the force of the wind. The barometer and wind table showed that whereas the barometric difference between Scilly and Falmouth was ·02 in. in 15 miles, and between Stonyhurst and Liverpool ·03 in. in 15 miles, the wind velocity at Scilly reached 78 miles an hour against a maximum of only 20 miles at Stonyhurst. He suggested that the real explanation of this fact was to be found in a consideration of the surrounding conditions of pressure. The Atlantic permanent anticyclone, which might be described as the parent of the storm area, showed its north-eastern spur extending over Spain, and its proximity would, more than the gradient, account for the extreme force of the wind on the southern and western sides of the disturbance, the anticyclone being the source from which the cyclone was supplied with energy. The anticyclone on the north-eastern side was too remote to exert any influence upon the wind velocity. Although Mr. Harding had traced the disturbance as far back as the neighbourhood of Newfoundland, the existence of the permanent anticyclone on the eastern side of the Atlantic was favourable to the origination of a storm in the Tropics, and thence taking a northerly course in mid-ocean it would reach Europe without approaching near enough to the American mainland to permit of our receiving telegraphic information of its existence.

Mr. **Dymond** thought that it might be worth while to make an investigation into the frequency of storms in the month of October. He had frequently noticed that from the 15th to the 17th of this month was characterised by very stormy weather.

Mr. **Symons** said that such an investigation as that suggested by Mr. Dymond had already been partly carried out in a paper written by himself, viz.: "Is the 'Royal Charter' Gale periodic?"

Mr. C. **Harding** in reply said that he believed the storm did not come from the Tropics, but originated some distance to the south-east of Newfoundland. This locality was a well-known breeding ground for storms. He believed the position of the anticyclone over Spain had a good deal to do with the violence of the storm over the British Isles, and doubtless this high pressure was part of the area which is usually permanent over the North Atlantic. The observations obtained from the ships' logs showed that at the period the whole high-pressure area had had a very easterly situation over the Atlantic; the barometer, however, had not been low in a corresponding latitude on the western side.

THE CLIMATE OF CARLISLE.

BY THOMAS G. BENN, F.R.MET.SOC.

[Read November 17th, 1886.]

THE meteorological observations taken at the Carlisle Cemetery were commenced in the year 1860, but during the first three years there were long and frequent breaks in the record. The continuity of the observations appears, however, to have been preserved since January, 1863, and those for the twenty-three years from that time up to, and including, 1885, have been employed for the purposes of this Paper.

The instruments in use have all been verified at the Kew Observatory. The barometer is a Fortin instrument hanging 114 ft. above mean sea-level. The out-door instruments are in a small but fairly well exposed enclosure near the main entrance to the Cemetery. The thermometer screen is an ecclesiastical-looking structure, having a sharp pointed roof, a double back, and is quite open at the front facing north, and although in keeping with the other objects around, might with advantage be replaced by a Stevenson screen. The thermometers include dry and wet bulbs, maximum and minimum, and solar and terrestrial radiation instruments, the last two being laid upon the grass. The rain gauge has a diameter of 8 ins., and its receiving funnel stands 4 feet above the ground. All the instruments were made by Messrs. Negretti and Zambra.

The observations were made twice daily, viz. at 9 a.m. and 9 p.m. by the Curator at the Cemetery, whom I have to thank for placing the records at my disposal.

The plan proposed in this inquiry is to discuss, first, the yearly and monthly periods; and second, the elements belonging to each of the four seasons.

Barometric Pressure.—The highest reading of the barometer occurred on January 18th, 1882, viz. 30·780 ins., and the lowest on January 26th, 1884, during the great storm of that date, when the reading was 27·898 ins. The absolute range of pressure was 2·882 ins. The means for each month reduced to 32° and Mean Sea-Level were as follows:—

	Ins.		Ins.
January	29·833	July	29·911
February... ...	29·880	August	29·877
March	29·845	September ...	29·863
April	29·908	October	29·823
May	29·951	November ...	29·860
June	29·939	December ...	29·853
Year	29·875 ins.		

The highest monthly mean was in May, viz. 29·951 ins., and the lowest in October, viz. 29·823 ins., the difference being 0·128 in. The three months of highest mean pressure were May, June, and July; a fall takes place during the next three months to the annual minimum in October.

Temperature of the Air.—The absolute highest temperature in the shade during the twenty-three years was 95°·0 on July 22nd, 1873, and the lowest was −5°·5 on January 16th, 1881, thus showing a range of 100°·5. On the grass the thermometer on the last named date fell to −10°·5, and on December 4th, 1879, a thermometer similarly exposed registered −4°·5.

The mean temperature for the whole period was 47°·5. The highest mean temperature was 49°·6 for 1868, and the lowest 45°·2 for 1879, the difference being 4°·4. The next warmest years were 1884 and 1872, the means of which were respectively 48°·7 and 48°·8; and the next coldest years were 1881 and 1885, when the mean temperatures were 45°·6 and 46°·1.

Dividing the whole into five periods we get the following result:—

°
3 years 1863 to 1865 the mean temperature was 47·5.
5 years 1866 to 1870 „ „ „ „ 48·2.
5 years 1871 to 1875 „ „ „ „ 47·8.
5 years 1876 to 1880 „ „ „ „ 46·9.
5 years 1881 to 1885 „ „ „ „ 47·1.

The period 1866 to 1870 had the highest mean temperature, and showed a rise from that of the three preceding years. The next two periods show a continuous and considerable decrease. The last five years show a slight recovery, although three out of the five years were colder than the mean.

The coldest month was January 1881, when the mean temperature was 25°·9, being 11°·9 below the average for the month; and the warmest month was July 1868, the mean temperature being 62°·9, or 3°·7 above the average for July. Thus the difference between the coldest and the warmest months was 37°·0. The next coldest months to January 1881 were December 1878, 26°·8; January 1879, 29°·5; and December 1874, 29°·8. The next warmest months were July, 1869, 1870, and 1874, when the means were respectively 61°·8, 61°·7, and 61°·6.

The month with the highest mean was July, 59°·2; whilst January, whose mean temperature is 37°·8, had the lowest, the difference being 21°·4. The average temperature of each month, together with the highest and lowest means which were observed during the period, were the following:—

TABLE I.

Temperature of the Air, 1863–1885.

Months.	Mean.	Highest Mean.	Year.	Lowest Mean.	Year.
	°	°		°	
January	37·8	42·8	1884	25·9	1881
February	39·9	44·2	1869	34·4	1873
March	40·7	44·8	1871	35·5	1883
April	45·9	48·8	1869	42·3	1877
May	50·1	54·2	1868	46·2	1869
June	56·1	58·2	1865 & 1879	53·0	1864
July	59·2	62·9	1868	53·6	1881
August	58·6	61·6	1884	55·2	1864
September	54·5	59·7	1865	50·8	1863
October	47·6	51·1	1876	42·2	1880
November	41·1	46·9	1881	37·0	1878
December	38·2	43·7	1868	26·8	1878

The months showing the greatest differences among the means are December and January, the differences between the highest and lowest means being in each case 16°·9, the coldest December being that of 1878, when the mean temperature was 26°·8, and the warmest that of 1868, when the mean was 43°·7. The lowest mean for January was 25°·9, which occurred in 1881, and the highest was that for 1884, when the value was 42°·8.

The months of least difference in mean temperature were June and August, the values being respectively 5°·2 and 6°·4. The coldest June occurred in 1864, viz. 53°·0, and the warmest in 1865 and 1879, in both of which years the mean was 58°·2. The coldest August was that of 1864, when the mean temperature was 55°·2, and the warmest that of 1884, the mean being 61°·6. January 1884 was warmer than either April 1877 or October 1880; and July 1881 was colder than May 1868, and than fourteen out of the twenty-three Septembers; and only 2°·5 warmer than October 1876. But the actual mean temperature is not the only, or even the most important, thing to be known in discussing the climate of a place. Two places may have exactly the same mean temperature, yet the respective mean maximum and mean minimum (from which the mean daily temperature is deduced) may differ most materially. The mean daily range of temperature has a most important influence on climate, on health, and on the growth and perfection of certain classes of plants. We shall return to this further on when discussing the elements peculiar to each season.

Rainfall.—The mean annual rainfall for the twenty-three years was 29·80 ins. The following are the mean annual amounts of rain at several places in the neighbourhood:—

	Ins.		Ins.
Kirkandrews ...	33·16	Seathwaite ...	143·21
Scaleby	33·95	Keswick	61·57
Wigton	35·80	Loweswater ...	58·83
Silloth	35·28	Penrith	31·20
Aspatria	34·55	Patterdale ...	85·86
Maryport	34·13	Hexham... ...	34·35
Cockermouth ...	44·24	Newcastle ...	29·06
Workington ...	33·58	Dumfries... ...	40·10

The means here given are for the twenty-four years ending with 1883.

By far the largest annual rainfall was that of 1877, viz. 44·63 ins., being more than double the amount for 1867, which was the driest year of the period, the fall being only 22·20 ins.

Dividing the whole into five periods as before we find that for the

	Ins.
3 years 1863 to 1865 the mean annual rainfall was	26·34
5 years 1866 to 1870 ,, ,, ,, ,, ,,	25·91
5 years 1871 to 1875 ,, ,, ,, ,, ,,	32·01
5 years 1876 to 1880 ,, ,, ,, ,, ,,	32·31
5 years 1881 to 1885 ,, ,, ,, ,, ,,	31·05

The period 1866 to 1870 was, therefore, the driest, and the five years 1876 to 1880 the wettest, and they correspond respectively with the periods of highest and lowest mean temperature.

The heaviest rainfall for any month was 7·84 ins. in July 1884, being 4·66 ins. in excess of the mean for the month. This exceedingly wet July was followed by the warmest August of the twenty-three years. The next wettest month was August 1877, viz. 7·39 ins. No month was without rain, the driest being January 1881, a month of intense frost, when 0·30 in. of rain fell, or 2·40 ins. below the average for the month; and the next driest was June 1884, with a fall of 0·36 in.

The average number of rainy days was 174. The year of greatest rainfall frequency was 1877, when there were 238 wet days, while in 1865 there were only 127.

The mean driest month was April, 1·67 in., and the wettest was August, when the average rainfall was 3·38 ins. The mean daily amount of rain in April was 0·056 in. and in August 0·110 in., being thus about double that of April.

The amount of rain which fell during the first six months from January to June, when the temperature was rising, was 12·08 ins., and for the last six months, when the temperature was falling, the mean amount was 17·78 ins.

TABLE II.

MONTHLY RAINFALL, 1863–1885.

Months.	Average Rainfall.	Greatest Rainfall.	Year.	Least Rainfall.	Year.
	Ins.	Ins.		Ins.	
January	2·70	5·84	1884	·30	1881
February	1·97	4·08	1869	·60	1873
March	1·70	3·26	1876	·47	1863
April	1·67	3·12	1882	·40	1873
May	1·88	5·09	1865	·94	1883
June	2·11	4·05	1872	·36	1884
July	3·18	7·84	1884	·43	1868
August	3·38	7·39	1877	1·21	1869
September	3·13	5·28	1883	·72	1865
October	3·01	5·12	1874	1·27	1866
November	2·68	6·04	1877	·48	1867
December	2·40	4·76	1868	·83	1870

There was more rain in July 1884 than falls on an average of years during the four months February, March, April, and May, and the month was equalled in this respect by August 1877; while the total fall for January 1881 and June 1884 was less than is frequently registered in one hour, and daily falls considerably in excess of that of any of the driest months have often occurred.

Having briefly discussed the observations as they refer to the yearly and monthly periods, we will next consider the characteristics of each of the four seasons.

Table III. gives a statement of the principal meteorological elements for each season, the values in all cases being the means for the twenty-three years. By "Winter" is meant the months of December, January, and February; "Spring"—March, April, and May; "Summer"—June, July, and August; and "Autumn"—September, October, and November. The observations for December 1862 are utilised in order to complete the record for the twenty-three winters.

Winter.—Dealing with the seasons in the order given above, we find that the mean winter temperature at Carlisle was 38°·7. The mean maximum

TABLE III.

	Winter.	Spring.	Summer.	Autumn.
	°	°	°	°
Temperature, Mean	38·7	45·6	58·0	47·7
„ Mean Max.........	44·1	54·2	67·8	55·2
„ Mean Min.	33·1	37·7	49·2	40·5
„ Mean Daily Range	11·0	16·5	18·6	14·7
„ Mean Dew-point ..	35·4	40·6	51·7	42·5
Relative Humidity	88	83	80	85
Mean Amount of Cloud (0–10)	7·6	6·9	7·0	6·9
	Ins.	Ins.	Ins.	Ins.
Rainfall........................	7·11	5·24	8·67	8·82
No. of Rainy Days	44	37	44	48
Wind, days N	4½	7	3	5
„ NE	2½	7	4	4
„ E	12	17	11	12
„ SE	9	6	3	6
„ S	13½	8	8	12
„ SW	13	10	13	11
„ W	19	23	33	22
„ NW	6½	6	4	5
„ Calm	10	8	13	14

was 44°·1, and the mean minimum 33°·1, giving a mean daily range of 11°·0. The mean dew-point was 35°·4, and the relative humidity 88 (complete saturation being 100). The average amount of cloud was 7·6. The mean winter rainfall was 7·11 ins., which fell on an average of forty-four days, and the most prevalent winds were South, South-west, and West.

The warmest Winter was that of 1868-9, when the mean temperature was 43°·3, being 4°·6 above the average. That Winter was warmer than the Springs of 1877 and 1883, and nearly as warm as the Spring of 1885. The coldest Winter occurred in 1878-79, the mean temperature on that occasion being only 30°·5, or 8°·2 below the average. The difference between the warmest and coldest Winters was 12°·8. The next mildest Winter was that of 1862-63, viz. 41°·9, and the next coldest, that of 1880-81, viz. 33°·8.

On comparing the periods as before, it is found that the five years 1866 to 1870 had the mildest Winters, viz. 40°·1. This was also the period of greatest winter rainfall. The five coldest Winters (between 1876 and 1880) had a mean temperature of 37°·4. The average winter temperature for the first thirteen years was 1°·0 higher than that for the last ten years.

The wettest Winter was that of 1876-77, but it was nearly equalled by that of 1868-69, the rainfall in each case being respectively 12·14 ins. and 11·29 ins. In the former case there were sixty-four, and in the latter fifty-nine rainy days. The Winter of least rainfall was that of 1878-79, which was also the coldest, the amount being only 3·90 ins., and there were only twenty-two wet days, fourteen of which occurred in February. The wettest and driest Winters had rainfalls respectively 5·03 ins. above and 3·21 ins. below the mean. The average winter rainfall for the first thirteen years was 0·39 in. less than that for the last ten years.

Spring.—The mean temperature for Spring was 45°·6. The mean maximum temperature was more than 10° higher than that for Winter, being 54°·2.

The mean minimum temperature showed that at sunrise the air was only 4°·6 warmer than at the same time in Winter, so that the mean daily variation of temperature was increased to 16°·5. The mean temperature of the dew-point had risen 5°·2, while the relative humidity had fallen 5 per cent. from the winter values. The mean amount of cloud was less than in Winter, being now 6·9. The Spring was the driest of the four seasons, the average rainfall being 5·24 ins., and the rainy days were less frequent, the average number being thirty-seven. Easterly winds occurred more frequently than at any other season, but the Westerly winds were, as at other seasons, most prevalent.

The warmest Spring was that of 1868, the mean temperature being 48°·5, or 2°·9 above the average; and the coldest occurred in 1877, the mean being 42°·9, and it was colder than the Winter of 1868-69. The difference between the warmest and coldest Springs was 5°·6. The next warmest Spring was that of 1871, viz. 47°·6, and the next coldest that of 1883, viz. 43°·0. The five consecutive years, 1871-75, had the highest mean spring temperature, viz. 46°·6, while for the five years 1876-80 the mean was 44°·8, that being the coldest period. These were respectively the periods of least and greatest mean spring rainfall. The mean spring temperature for the thirteen years 1863 to 1875 was 1°·3 higher than for the ten years 1876 to 1885.

The wettest Spring occurred in 1868, and was followed by the warmest Summer of the whole period. The rainfall on that occasion was 8·06 ins., which fell on forty-two days. The driest Spring was that of 1875, when there was a total rainfall of only 3·00 ins. on thirty-four days. These amounts were respectively 2·82 ins. above, and 2·24 ins. below the average. The mean spring rainfall for the last ten years had increased by 0·68 in. compared with the first thirteen years.

Summer.—Coming now to the summer season, we find that the mean temperature rose nearly 20° above that of the winter quarter, being 58°. The average maximum temperature was 67°·8, while just before sunrise the thermometer fell to a mean of 49°·2, the resulting mean daily range being thus 18°·6. The dew-point temperature was 51°·7 (whereas in Winter it was 35°·4), and the relative humidity of the atmosphere was 80 per cent. The mean amount of cloud was 7·0. Rainfall had increased considerably, the average amount being 8·67 ins., which exceeded the winter rainfall by 1·56 ins. and that of Spring by 3·43 ins. The mean number of rainy days was the same as in Winter, viz. 44, while West, South-west, and East winds prevailed most frequently in the order named.

The warmest Summer occurred in 1868, which year had also the warmest and the wettest Spring. The mean temperature of the Summer of that year was 60°·5, or 2°·5 above the average. The coldest Summer was that of 1881, the mean being only 55°·0 and 3°·0 below the average. The difference between the warmest and coldest Summers was 5°·5, less than half the difference between the mildest and coldest Winters. The next warmest and coldest Summers were respectively those of 1878 and 1864, whose mean temperatures were 59°·8 and 55°·2. Of the five-year periods, that from 1866 to 1870 had the warmest Summers, viz. 58°·7, and the period 1881 to 1885 had the coldest, viz. 57°·1. The mean Summer temperatures for the first thirteen and the last ten years were nearly identical, the last named period showing a fall of 0°·1.

The Summer of greatest rainfall was that of 1877, and this fall was much heavier than that of any Winter, Spring, or Autumn during the twenty-three years. The amount was 15·04 ins. which fell on sixty-two out of the ninety-two days, and that exceedingly wet Summer followed the coldest Spring, and preceded one of the wettest Autumns, included in the whole period. The driest Summer occurred in 1869, the amount being only 3·66 ins. on twenty-nine days —less than one-fourth the amount for 1877. These extremes of rainfall were respectively 6·37 ins. above and 5·01 ins. below the average for the Summer season. The mean summer rainfall for the last ten years was 2·68 ins. more than the mean for the first thirteen years.

Autumn.—The mean autumn temperature was 10°·8 below that of Summer, but was 2°·1 higher than that of the spring quarter, the value being 47°·7. The mean maximum temperature was 1°·0 higher than in Spring, being 55°·2, while the mean minimum temperature was 2°·8 higher, viz. 40°·5. The mean daily range of temperature was 14°·7. The mean dew-point temperature was 42°·5, and the relative humidity 85. The average amount of cloud was 6·9, which is exactly the same as in Spring. This was the season of greatest rainfall, the average amount being 8·82 ins. Rainy days were also more frequent than at any other season, the average number being forty-eight. Westerly winds were most prevalent, next to which came Easterly and Southerly with about equal frequency.

The warmest Autumn was that of 1865, viz. 49°·8. The Autumns of 1880 and 1885 were the coldest, the mean temperature in each case being 46°·0. These values are respectively 2°·1 above and 1°·7 below the mean, and the difference between the warmest and coldest Autumns was 3°·8. The next warmest Autumn occurred in 1866, and the next coldest in 1873, the means being 49°·0 and 46°·3. Dividing into the three and five year periods, as before, we find a continuous decrease in autumn temperature from 1863 to 1880. The mean for the first three years was 48°·5, falling continuously to 47°·1 for the years 1876-80. The last five years show some recovery, the average being 47°·8. The first thirteen years showed a mean autumn temperature 0°·6 higher than the last ten years.

The wettest Autumn occurred in 1874, when there were 12·78 ins. of rain on sixty-two days. The next wettest were 1883 and 1877, in which years there were respectively 12·54 ins. and 12·29 ins. The driest Autumn was that of 1867, when there were only 4·69 ins. on thirty-nine days, and next to it, in point of dryness, was 1879 with 5·27 ins. on thirty-five days. The amounts for the driest and wettest Autumns were respectively 4·13 ins. below, and 3·96 ins. above the average. The mean rainfall for the last ten Autumns was less than that for the first thirteen by 0·20 in.

The general result of the foregoing investigations points to the fact that, comparing the thirteen years 1863 to 1875 with the ten years 1876 to 1885, the mean annual temperature has decreased 0°·9, while concurrently with this, the average yearly rainfall has increased by 3·33 ins. With respect to the seasons, the mean temperature of Winter and Spring is decidedly lower in the latter period, and so in a less degree is that of Summer and Autumn also; while in the matter of rainfall, the Summer has been decidedly wetter, Winter and Spring a little wetter, and Autumn a little drier in the last ten years. Speaking generally, those Summers which have been more than usually cold have been accompanied by a large quantity of rain; while in Winter the conditions are reversed, and warmth and wet usually go together.

RESULTS OF HOURLY READINGS,

Derived from a Redier Barograph at Geldeston, Norfolk,

During Four Years ending February, 1886.

BY E. T. DOWSON, F.R.MET.SOC.

[Read November 17th 1886.]

In 1875[1] Mr. Symons, F.R.S., read a paper containing a description of the Redier Barograph, and notices of its results have since been published.[2] The tabulations, obtained in the same manner as previously described,[2] have now extended over four years, and the differences from the mean of the readings of the standard barometer are as follows:—

		In.		In.
1882-3	9 a.m.	—·002	9 p.m.	—·002
1883-4		—·002		—·003
1884-5		—·002		—·003
1885-6		—·001		—·002
Mean		—·002		—·002

In no month at either of these hours has the difference from the standard mean exceeded —·007 in.

Geldeston is situated at about nine miles from the sea; and as seen in the accompanying Table the mean monthly and seasonal curves, so far as they go, bring out amongst others the following points, viz.:—

1. The P.M. Minimum has the greater amplitude in April, July, August, and especially in January: on the other hand, in February and October the A.M. Minimum is the most pronounced.

2. The P.M. Maximum has somewhat the greater amplitude in February (where it occurs at midnight), May, September and October; in January

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[1] *Quarterly Journal*, Vol. II. p. 412.

[2] Vol. IX. p. 180, and *Meteorological Record*, 1883, p. 54.

TABLE I.—MEAN HOURLY READINGS OF THE BAROMETER AT GELDESTON, NORFOLK, MARCH 1882—FEBRUARY 1886.

Month and Year.		1 a.m.	2 a.m.	3 a.m.	4 a.m.	5 a.m.	6 a.m.	7 a.m.	8 a.m.	9 a.m.	10 a.m.	11 a.m.	Noon.	1 p.m.	2 p.m.
		Ins.	Ins.	Ins.	Ins.	Ins,	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
March	1882......	29·961	29·959	29·952	29·948	29·949	29·950	29·955	29·963	29·969	29·976	29·979	29·976	29·972	29·965
	1883......	29·918	29·912	29·906	29·903	29·903	29·905	29·912	29·915	29·920	29·922	29·920	29·919	29·915	29·907
	1884......	29·936	29·931	29·926	29·921	29·920	29·922	29·925	29·929	29·933	29·933	29·934	29·931	29·927	29·922
	1885......	30·060	30·056	30·049	30·046	30·045	30·046	30·049	30·055	30·059	30·062	30·062	30·061	30·056	30·049
April	1882......	29·765	29·765	29·763	29·761	29·765	29·770	29·776	29·780	29·785	29·791	29·791	29·788	29·786	29·781
	1883......	30·014	30·010	30·006	30·004	30·004	30·011	30·014	30·018	30·020	30·021	30·016	30·012	30·008	30·002
	1884......	29·828	29·824	29·819	29·817	29·817	29·822	29·827	29·831	29·835	29·836	29·836	29·835	29·833	29·830
	1885......	29·802	29·796	29·790	29·786	29·785	29·788	29·794	29·798	29·802	29·802	29·801	29·799	29·794	29·790
May	1882......	30·048	30·044	30·040	30·038	29·764	30·046	30·049	30·056	30·058	30·057	30·055	30·052	30·048	30·047
	1883......	29·938	29·935	29·932	29·928	29·970	29·937	29·941	29·946	29·949	29·950	29·949	29·947	29·945	29·943
	1884......	29·968	29·968	29·965	29·966	29·932	29·976	29·982	29·987	29·989	29·992	29·993	29·991	29·987	29·982
	1885.....	29·781	29·776	29·770	29·765	30·043	29·769	29·772	29·776	29·777	29·780	29·780	29·779	29·779	29·777
June	1882......	29·871	29·864	29·863	29·862	29·865	29·868	29·871	28·874	29 880	29·882	29·885	29·885	29·882	29·882
	1883......	29·967	29·961	29·957	29·957	29·957	29·960	29·963	29·968	29·969	29·971	29·972	29·970	29·969	29·967
	1884......	30·022	30·015	30·012	30·012	30·014	30·017	30·021	30·025	30·027	30·028	30·029	30·028	30·025	30·025
	1885......	30·025	30·020	30·016	30·014	30·017	30·019	30·024	30·026	30·030	30·029	30·030	30·028	30·026	30·023
July	1882......	29·848	29·844	29·841	29·841	29·846	29·851	29·857	29·862	29·862	29·862	29·862	29·861	29·857	29·853
	1883......	29·830	29·824	29·819	29·820	29·820	29·822	29·826	29·829	29·831	29·829	29·829	29·829	29·828	29·826
	1884......	29·946	29·941	29·937	29·937	29·941	29·943	29·948	29·952	29·952	29·951	29·950	29·946	29·942	29·939
	1885......	30·166	30·162	30·160	30·160	30·160	30·164	30·168	30·172	30·175	30·174	30·173	30·171	30·168	30·168
August	1882	29·882	29·875	29 868	29·866	29·865	29·867	29·867	29·869	29·873	29·873	29·873	29·874	29·873	29·872
	1883......	29·985	29·982	29·976	29·973	29 976	29·982	29·986	29·992	29·993	29·992	29·990	29·988	29·986	29·981
	1884......	30·022	30·017	30·012	30·009	30·009	30·010	30·013	30·016	30·019	30·021	30·018	30·018	30·014	30·010
	1885......	29·970	29·965	29·962	29·957	29·957	29·961	29·962	29·965	29·970	29·971	29·970	29·969	29·969	29·968

TABLE I.—MEAN HOURLY READINGS OF THE BAROMETER AT GELDESTON, NORFOLK, MARCH 1882—FEBRUARY 1886—*Continued.*

Month and Year.		3 p.m.	4 p.m.	5 p.m.	6 p.m.	7 p.m.	8 p.m.	9 p.m.	10 p.m.	11 p.m.	Mid.	Mean.	Extremes.	
													Max.	Min.
		Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
March	1882..........	29·961	29·958	29·959	29·965	29·974	29·978	29·982	29·983	29·985	29·984	29·967	30·620	28·820
	1883..........	29·903	29·899	29·899	29·905	29·909	29·914	29·916	29·916	29·915	29·914	29·911	30·740	29·160
	1884..........	29·917	29·916	29·917	29·922	29·929	29·931	29·932	29·932	29·929	29·927	29·927	30·210	29·180
	1885..........	30·045	30·042	30·045	30·049	30·057	30·061	30·064	30·065	30·064	30·061	30·055	30·590	29·200
April	1882..........	29·776	29·771	29·766	29·766	29·767	29·771	29·772	29·769	29·768	29·768	29·773	30·410	28·950
	1883..........	29 996	29·992	29·991	29·993	29·997	30·001	30·005	30·007	30·006	30·004	30·006	30·645	29·410
	1884..........	29·827	29·823	29·824	29·826	29·832	29·837	29·840	29·840	29·841	29·840	29·830	30·080	29·360
	1885..........	29·786	29·785	29·784	29·785	29·788	29·796	29·799	29·799	29·798	29·797	29·794	30·330	29·285
May	1882..........	30·046	30·045	30·047	30·049	30·053	30·061	30·069	30·070	30·070	30·070	30·053	30·480	29·320
	1883..........	29·940	29·937	29·935	29·938	29·944	29·949	29·955	29·956	29·955	29·954	29·943	30·410	29·480
	1884..........	29·979	29·973	29·969	29·966	29·968	29·973	29·978	29·979	29·980	29·978	29·977	30·465	29·255
	1885..........	29·776	29·776	29·776	29·776	29·780	29·787	29·795	29·797	29·798	29·798	29·779	30·190	29·170
June	1882..........	29·878	29·876	29·873	29·872	29·872	29·872	29·878	29·875	29·870	29·867	29·874	30·360	29·350
	1883..........	29·965	29·962	29·960	29·960	29·962	29·966	29·973	29·973	29·971	29·968	29·965	30·370	29·585
	1884..........	30·023	30·021	30·018	30·018	30·020	30·025	30·030	30·031	30·030	30·028	30·023	30·350	29·580
	1885..........	30·020	30·018	30·015	30·014	30·015	30·017	30·024	30·028	30·027	30·028	30·022	30·390	29·420
July	1882..........	29·850	29·845	29 841	29·842	29·845	29·848	29·853	29·857	29·857	29·855	29·852	30·470	29·315
	1883..........	29·822	29·818	29·816	29·816	29·820	29·823	29·829	29·830	29·830	29·828	29·825	30·130	29·445
	1884..........	29·935	29·932	29.928	29·929	29·932	29·938	29·944	29·948	29·950	29·949	29·942	30·210	29·630
	1885..........	30·166	30·164	30·161	30·166	30·162	30·164	30·171	30·173	30·173	30·171	30·167	30·480	29·795
August	1882..........	29·869	29·869	29·869	29·871	29·873	29·880	29·882	29·882	29·879	29·877	29·873	30·265	29·120
	1883..........	29·978	29·975	29·973	29·972	29·975	29·981	29·983	29·982	29·981	29·979	29·982	30·295	29·510
	1884..........	30·005	30·001	29·998	29·997	30·000	30·007	30·011	30·011	30·012	30·010	30·011	30·270	29·630
	1885..........	29·966	29·964	29·961	29·961	29·964	29·969	29·972	29·973	29·972	29·971	29·966	30·330	29·600

TABLE I.—MEAN HOURLY READINGS OF THE BAROMETER AT GELDESTON, NORFOLK, MARCH 1882—FEBRUARY 1886—*Continued.*

Month and Year.	1 a.m.	2 a.m.	3 a.m.	4 a.m.	5 a.m.	6 a.m.	7 a.m.	8 a.m.	9 a.m.	10 a.m.	11 a.m.	Noon.	1 p.m.	2 p.m.
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
September 1882 ..	29·853	29·848	29·841	29·836	29·836	29·838	29·840	29·842	29·844	29·845	29·844	29·843	29·842	29·841
1883 ..	29·811	29·806	29·800	29·796	29·794	29·796	29·800	29·801	29·806	29·804	29·803	29·801	29·798	29·798
1884 ..	29·993	29·989	29·986	29·983	29·981	29·985	29·989	29·996	30·003	30·005	30·003	30·001	29·997	29·993
1885 ..	29·875	29·867	29·860	29·855	29·852	29·853	29·857	29·863	29·869	29·869	29·870	29·867	29·864	29·860
October 1882 ..	29·830	29·832	29·826	29·827	29·827	29·826	29·831	29·833	29·837	29·840	29·835	29·828	29·820	29·813
1883 ..	29·919	29·915	29·910	29·905	29·905	29·906	29·913	29·922	29·934	29·940	29·943	29·940	29·939	29·936
1884 ..	30·010	30·005	30·001	29·997	29·997	30·000	30·006	30·015	30·024	30·028	30·027	30·024	30·021	30·020
1885 ..	29·661	29·657	29·652	29·650	29·651	29·653	29·658	29·665	29·668	29·671	29·673	29·668	29·665	29·661
November 1882 ..	29·625	29·622	29·615	29·609	29·609	29·613	29·620	29·634	29·646	29·651	29·656	29·653	29·650	29·646
1883 ..	29·800	29·796	29·791	29·785	29·782	29·781	29·781	29·785	29·786	29·787	29·785	29·777	29·771	29·768
1884 ..	30·141	30·140	30·135	30·132	30·134	30·136	30·138	30·142	30·147	30·148	30·148	30·137	30·129	30·124
1885 ..	29·900	29·900	29·898	29·894	29·894	29·894	29·898	29·904	29·910	29·911	29·909	29·902	29·897	29·890
December 1882 ..	29·640	29·641	29·641	29·639	29·635	29·632	29·633	29·639	29·649	29·655	29·654	29·650	29·641	29·637
1883 ..	30·068	30·068	30·066	30·062	30·060	30·061	30·067	30·079	30·090	30·097	30·098	30·092	30·084	30·084
1884 ..	29·836	29·833	29·832	29·826	29·821	29·820	29·820	29·822	29·828	29·833	29·835	29·826	29·817	29·809
1885 ..	30·158	30·160	30·158	30·157	30·154	30·154	30·159	30·167	30·178	30·185	30·185	30·180	30·170	30·164
January 1883 ..	29·882	29·882	29·884	29·887	29·885	29·889	29·895	29·905	29·914	29·920	29·920	29·912	29·904	29·897
1884 ..	30·035	30·038	30·038	30·035	30·032	30·033	30·038	30·043	30·056	30·057	30·056	30·042	30·031	30·022
1885 ..	29·923	29·920	29·919	29·912	29·907	29·906	29·907	29·910	29·915	29·916	29·914	29·904	29·893	29·882
1886 ..	29·636	29·636	29·634	29·627	29·623	29·620	29·620	29·621	29·625	29·629	29·629	29·621	29·614	29·607
February 1883 ..	30·053	30·050	30·047	30·042	30·043	30·042	30·049	30·057	30·064	30·068	30·072	30·068	30·063	30·063
1884 ..	29·909	29·908	29·903	29·898	29·899	29·902	29·906	29·915	29·923	29·927	29·930	29·927	29·921	29·915
1885 ..	29·682	29·685	29·685	29·688	29·693	29·696	29·701	29·706	29·711	29·713	29·715	29·713	29·704	29·697
1886 ..	30·112	30·111	30·107	30·105	30·107	30·107	30·112	30·119	30·126	30·129	30·131	30·128	30·123	30·117

TABLE I.—MEAN HOURLY READINGS OF THE BAROMETER AT GELDESTON, NORFOLK, MARCH 1882—FEBRUARY 1886—*Continued.*

Month and Year.		3 p.m.	4 p.m.	5 p.m.	6 p.m.	7 p.m.	8 p.m.	9 p.m.	10 p.m.	11 p.m.	Mid.	Mean.	Extremes.	
													Max.	Min.
		Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
September	1882......	29·839	29·839	29·842	29·845	29·852	29·858	29·858	29·859	29·856	29·854	29·846	30·395	29·200
	1883......	29·797	29·795	29·797	29·802	29·808	29·815	29·816	29·816	29·815	29·814	29·803	30·255	28·850
	1884......	29·988	29·987	29·989	29·993	30·000	30·004	30·008	30·009	30·008	30·007	29·996	30·365	29·290
	1885......	29·856	29·854	29·853	29·855	29·860	29·864	29·868	29·868	29·866	29·862	29·862	30·340	29·250
October	1882......	29·812	29·815	29·819	29·827	29·831	29·833	29·836	29·836	29·836	29·836	29·829	30·510	28·740
	1883......	29·933	29·931	29·935	29·940	29·941	29·943	29·945	29·945	29·945	29·945	29·930	30·490	29·190
	1884.....	30·016	30·016	30·020	30·025	30·027	30·031	30·031	30·028	30·024	30·022	30·017	30·645	29·265
	1885......	29·663	29·665	29·667	29·671	29·672	29·672	29·673	29·671	29·668	29·666	29·664	30·210	28·950
November	1882......	29·649	29·650	29·652	29·650	29·647	29·644	29·639	29·637	29·636	29·632	29·637	30·090	29·065
	1883......	29·770	29·773	29·781	29·787	29·793	29·797	29·800	29·800	29·800	29·797	29·786	30·395	28·910
	1884......	30·121	30·122	30·123	30·127	30·129	30·131	30·135	30·136	30·135	30·135	30·134	30·560	29·645
	1885......	29·888	29·890	29·894	29·899	29·904	29·908	29·911	29·916	29·917	29·918	29·902	30·440	29·180
December	1882......	29·639	29·641	29·641	29·642	29·645	29·646	29·646	29·646	29·642	29·638	29·642	30·335	28·955
	1883......	30·091	30·095	30·099	30·102	30·105	30·105	30·104	30·100	30·097	30·092	30·086	30·580	29·260
	1884......	29·807	29·810	29·812	29·819	29·829	29·836	29·841	29·846	29·849	29·849	29·827	30·360	28·700
	1885.....	30·163	30·162	30·160	30·159	30·159	30·162	30·163	30·162	30·164	30·161	30·164	30·510	29·310
January	1883......	29·898	29·896	29·897	29·897	29·896	29·894	29·890	29·885	29·881	29·877	29·895	30·690	28·945
	1884......	30·020	30·015	30·011	30·012	30·010	30·010	30·009	30·010	30·012	30·010	30·026	30·615	28·435
	1885......	29·879	29·877	29·877	29·876	29·880	29·883	29·886	29·889	29·889	29·885	29·898	30·420	28·720
	1886......	29·607	29·608	29·611	29·614	29·617	29·618	29·620	29·618	29·617	29·613	29·620	30·070	28·970
February	1883......	30·063	30·056	30·059	30·065	30·069	30·071	30·075	30·078	30·078	30·083	30·062	30·775	29·000
	1884......	29·912	29·912	29·915	29·919	29·923	29·925	29·928	29·927	29·926	29·926	29·917	30·410	29·355
	1885......	29·694	29·694	29·696	29·704	29·707	29·709	29·711	29·711	29·712	29·714	29·702	30·240	29·085
	1886......	30·115	30·117	30·122	30·128	30·134	30·136	30·139	30·141	30·143	30·144	30·123	30·760	29·125

TABLE II.—Monthly Mean Hourly Readings of the Barometer.

Months.	1 a.m.	2 a.m.	3 a.m.	4 a.m.	5 a.m.	6 a.m.	7 a.m.	8 a.m.	9 a.m.
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
March ..	29·969	29·965	29·958	29·955	29·954[2]	29·956	29·960	29·966	29·970
April	·852	·849	·845	·842[2]	·843	·848	·853	·857	·861
May	·934	·931	·927	·924[2]	·927	·932	·936	·941	·943
June	·971	·965	·962	·961[2]	·963	·966	·970	·973	·977
July	·948	·943	·939[2]	·940	·942	·945	·950	·954	·955[1]
August ..	·965	·960	·955	·951[2]	·952	·955	·957	·961	·964[1]
September	·883	·878	·872	·868	·866[2]	·868	·872	·876	·881[1]
October ..	·855	·852	·847	·845[2]	·845[2]	·846	·852	·859	·866
November	·867	·865	·860	·855[2]	·855[2]	·856	·859	·866	·872
December	·926	·926	·924	·921	·918	·917[2]	·920	·927	·936
January..	·869	·869	·869	·865	·862[2]	·862[2]	·865	·870	·878
February	29·939	29·939	29·936	29·933[2]	29·936	29·937	29·942	29·949	29·956
Mean	29·915	29·912	29·908	29·905[2]	29·905[2]	29·907	29·912	29·917	29·922

Months.	10 a.m.	11 a.m.	Noon.	1 p.m.	2 p.m.	3 p.m.	4 p.m.	5 p.m.	6 p.m.
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
March ..	29·973	29·974[1]	29·972	29·968	29·961	29·957	29·954[2]	29·955	29·960
April	·863[1]	·861	·859	·855	·851	·846	·843	·841[2]	·843
May	·945[1]	·944	·942	·940	·937	·935	·933	·932[2]	·932[2]
June	·978	·979[1]	·978	·976	·974	·972	·969	·967	·966[2]
July	·954	·954	·952	·949	·947	·943	·940	·937[2]	·937[2]
August ..	·964[1]	·963	·962	·961	·958	·955	·952	·950[2]	·950[2]
September	·881[1]	·880	·878	·875	·873	·870	·869[2]	·870	·874
October ..	·870[1]	·870[1]	·865	·861	·858	·856[2]	·857	·860	·866
November	·874	·875[1]	·867	·862	·857[2]	·857[2]	·859	·863	·866
December	·943[1]	·943[1]	·937	·928	·924[2]	·925	·927	·928	·931
January..	·881[1]	·880	·870	·861	·852	·851	·849[2]	·849[2]	·850
February	29·959	29·962[1]	29·959	29·953	29·948	29·946	29·945[2]	29·948	29·954
Mean	29·924[1]	29·924[1]	29·920	29·916	29·912	29·909	29·908[2]	29·908[2]	29·911

Months.	7 p.m.	8 p.m.	9 p.m.	10 p.m.	11 p.m.	Mid.	Mean.	Extremes.	
								Max.	Min.
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
March ..	29·967	29·971	29·974[1]	29·974[1]	29·973	29·972	29·965	30·740	28·820
April	·846	·851	·854[1]	·854[1]	·853	·852	·851	·645	28·950
May	·936	·943	·949	·951[1]	·951[1]	·950	·938	·480	29·170
June	·967	·970	·976	·977[1]	·975	·973	·971	·390	·350
July	·940	·943	·949	·952	·953[1]	·951	·947	·480	·315
August ..	·953	·959	·962[1]	·962[1]	·961	·959	·958	·330	29·120
September	·880	·885	·888[1]	·888[1]	·886	·884	·877	·395	28·850
October ..	·868	·870	·871[1]	·870	·868	·867	·860	·645	·740
November	·868	·870	·871	·872[1]	·872[1]	·871	·865	·560	·910
December	·935	·937	·939[1]	·939[1]	·938	·935	·930	·580	·700
January	·851[2]	·851[1]	·851[1]	·851[1]	·850	·846	·860	·690	28·435
February	29·958	29·960	29·963	29·964	29·965	29·967[1]	29·951	30·775	29·000
Mean	29·914	29·918	29·920	29·921[1]	29·920	29·919	29·914	30·775	28·435

[1] Max. and [2] Min.

the A.M. Maximum is very distinct, whilst the P.M. is scarcely visible ; in April also the A.M. Maximum is considerably above the P.M.

8. In the mean annual curve the A.M. Minimum and Maximum have slightly the greater amplitude, and this is so in the Winter and Spring

TABLE III.—Annual Mean Hourly Readings of the Barometer.

March 1 to Feb. 28.	1 a.m.	2 a.m.	3 a.m.	4 a.m.	5 a.m.	6 a.m.	7 a.m.	8 a.m.	9 a.m.
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
1882–3	29·855	29·852	29·848	29·846[2]	29·847	29·849	29·854	29·860	29·865
1883–4	·933	·930	·925	·922[2]	·922[2]	·925	·929	·934	·940
1884–5	·942	·939	·935	·933[2]	·934	·936	·940	·944	·949
1885–6	29·929	29·926	29·921	29·918	29·917[2]	29·919	29·923	29·928	29·932
Mean ..	29·915	29·912	29·908	29·905[2]	29·905[2]	29·907	29·912	29·917	29·922

March 1 to Feb. 28.	10 a.m.	11 a.m.	Noon.	1 p.m.	2 p.m.	3 p.m.	4 p.m.	5 p.m.	6 p.m.
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
1882–3	29·868	29·869[1]	29·866	29·862	29·858	29·857	29·855[2]	29·855[2]	29·858
1883–4	·941[1]	·941[1]	·937	·933	·929	·927	·925[2]	·926	·929
1884–5	·950[1]	·950[1]	·946	·941	·936	·933	·931[2]	·931[2]	·934
1885–6	29·934[1]	29·934[1]	29·934[1]	29·927	29·923	29·921	29·920[2]	29·921	29·923
Mean ..	29·924[1]	29·924[1]	29·920	29·916	29·912	29·909	29·908[2]	29·908[2]	29·911

March 1 to Feb. 28.	7 p.m.	8 p.m.	9 p.m.	10 p.m.	11 p.m.	Mid.	Mean.	Extremes.	
								Max.	Min.
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
1882–3	29·860	29·863	29·865[1]	29·865[1]	29·863	29·862	29·858	30·775	28·740
1883–4	·932	·935	·939[1]	·939[1]	·938	·936	·932	·740	·435
1884–5	·938	·942	·946	·947[1]	·947[1]	·945	·940	·645	·700
1885–6	29·926	29·930	29·933	29·934[1]	29·934[1]	29·933	29·927	30·760	28·950
Mean ..	29·914	29·918	29·920	29·921[1]	29·920	29·919	29·914	30·775	28·435

[1] Max. and [2] Min.

months, but in the Autumn as regards the Minimum only. In the Summer the curve is very even.

4. In the Spring and Summer the A.M. Minimum occurs earlier, and the P.M. later than at other seasons. The hours of the two Maxima do not present any material seasonal variation.

5. The Range is ·028 in. in Winter, ·022 in. in Autumn, ·020 in. in Spring, ·014 in. in Summer, and in the annual curve ·019 in.

DISCUSSION.

Mr. Bayard said that he was much obliged for the opportunity which this paper afforded of bringing before the Meeting his own researches on the same subject, together with the discoveries which had arisen and the difficulties which presented themselves. He had been engaged for some months past in reducing, for a paper on the Diurnal Range of the Barometer, the hourly observations of the barometer at the several observatories in connection with the Meteorological Office for the lustrum 1876-1880. Three years were finished, viz. 1876 by Mr. Eaton, and 1877 and 1878 by himself. He had also obtained the reductions for the same lustrum of the Liverpool Observatory results at Bidston, and hoped eventually to obtain those for Greenwich. Mr. Bayard invited attention to a number of diagrams, there being three of these for each of the observatories of Valencia, Armagh, Glasgow, Aberdeen, Falmouth, Stonyhurst and Kew, and six for the observatory at Bidston. In each set of diagrams there appeared a third small maximum at about 3 a.m. in the winter months of January and December. This maximum was, however, much more marked at Valencia, Falmouth and Kew than at the other places, and it appeared in a slight degree in the five-year result at Bidston. It appeared also in the Greenwich Reductions, and also slightly in Mr. Dowson's results. This, however, entirely confirmed the view expressed by Mons. Rykatchew, "that this third maximum was much more pronounced in lower latitudes than in the higher ones." From the results of the five years at Bidston, it was noticed that the afternoon minimum was lower than the morning minimum in the first six months, with the exception of the month of January; and in the last six months the morning minimum was the lowest in every month with the exception of the month of November. The anomalies in these two months of January and November were explained by looking at the diagram for 1877. He believed that he was the first to notice this. Mr. Bayard next referred to the difficulties that he experienced in this work, and hoped to have the opinion of the Fellows as to the best way of dealing with them. The first difficulty was this: Should the results obtained by the calculation be corrected for periodicity? By periodicity he meant this: It does not at all follow that the mean for 0 hours is the same as the mean for midnight, because the hour from 0 to 1 a.m. does not come into the period calculated. Periodicity, therefore, divides itself into two parts: (1) the calculation of the 0 hour and (2) the elimination of the non-periodic part, which is done practically by turning the curve on its noon point by means of the following formula :—

$$\begin{array}{lll}
0 \text{ hour} & + 12 & \frac{24\text{ hs.} - 0\text{ h.}}{24} \\
1 \;\;\text{,,} & + 11 & \frac{24\text{ hs.} - 0\text{ h}}{24} \\
11 \;\;\text{,,} & +\ 1 & \frac{24\text{ hs.} - 0\text{ h.}}{24} \\
12 \;\;\text{,,} & \quad 0 & \quad 0 \\
13 \;\;\text{,,} & -\ 1 & \frac{24\text{ hs.} - 0\text{ h.}}{24} \\
24 \;\;\text{,,} & - 12 & \frac{24\text{ hs.} - 0\text{ h.}}{24}
\end{array}$$

This was Mons. Rykatchew's method, who claimed to have first discovered it Mr. Bayard believed that Gen. Strachey had a similar method, and that Prof. Ekholm of Upsala had another method. All these three methods had, practically, the same result, namely, to make the 0 hour and the midnight start and end at the same point. He (Mr. Bayard) thought that it would be a good thing to calculate the 0 hour, but as to the rest of the process he had great doubts, for it imported into the calculated means what is not there originally, as could be seen by looking at the curves.

The second difficulty was this: By the kindness of the Meteorological Council, he was enabled to lay before the Meeting some of the results of the Harmonic Analyser at the Meteorological Office; and he wished to have the advice of the Fellows on the results, as to whether they could be considered trustworthy. The Harmonic Analyser was supposed to produce accurately Bessel's constants up to the third term. By means of Bessel's formula the hourly values may be obtained. The constants may be corrected or not for periodicity, as thought desirable. Mons. Rykatchew throws great doubt on Bessel's formula for setting forth the diurnal curve of the barometer. He says that Prof. Ragona, of Modena, calculated the hourly values of the observations of the barometer at Modena, and he found there the third maximum, above referred to, in January. Prof. Ragona then calculated Bessel's constants to the fourth term (the Harmonic Analyser only goes to the third term), and he found that this third maximum disappeared. Prof. Ragona then thought that the third maximum was accidental, but being urged by Mons. Rykatchew, he again calculated the Modena observations for another period with the same result, namely, the finding of the third maximum in Winter. Prof. Ragona therefore came to the conclusion that the third maximum was a fact, and that Bessel's formula did not indicate the true diurnal range of the barometer even when the constants were calculated as far as the 5th and 6th terms, for the third maximum still disappeared. He also found that the curve calculated from the constants differed from that calculated from the observations, in that the morning maximum from the observations arrived sooner than that from the constants, and that the maximum from the constants was less than that which is observed, and that between 5 and 6 p.m. the observations give a greater height to the barometer, and between 7 and 8 p.m. a smaller one than the values according to the constants. These remarks of Mons. Rykatchew agree entirely with Mr. Bayard's views, so far as he is capable of ascertaining the differences from the facts now before him. The Meteorological Council have kindly offered him the Bessel's constants as obtained by the Harmonic Analyser for the temperature of the five years 1876-80, and in order to aid him, have further had the temperature results of Mr. Eaton's work in 1876 and the constants of the temperature placed side by side in order to give him a true insight into their value. The result shown in this curve, however, seemed rather to show that Bessel's formula was not adapted for the diurnal range of temperature so well as of the barometer, but before expressing a fixed opinion, he should like to go more fully into this at some future time. In conclusion, he wished to have the opinion of the Fellows on the following questions:—1. Having regard to the curves showing the results of (*a*) the Harmonic Analyser corrected for periodicity, (*b*) The actual hourly means corrected for periodicity, and (*c*) the actual hourly means uncorrected—which of these should be adopted as giving the most reliable and accurate data? 2. In drawing the curves, should they be limited to the twenty-four hours, 1 a.m. to midnight only, or should they be extended a few hours at each end? 3. If it is desirable that the curves should be extended, in what way should this be done? Should it be done by merely reproducing at each end the form of curve obtained from the actual hourly means, or by periodicity as mentioned in the first question? 4. If the latter (that is by periodicity), should the tables be corrected accordingly?

Lieut.-Gen. STRACHEY said that there appeared to be a fundamental misconception as to the application of Bessel's formula to meteorological records. This formula, which merely embodied a mathematical truth, enabled us to represent, to any desired degree of approximation, any series of values, supposed to be recurrent after a definite period, by means of a series of multiples of the sines and cosines of a series of angles, which represent the intervals from the commencement of the period at which the successive values are taken. He then explained by means of diagrams how the daily temperature curve could be represented by a series of curves drawn so as to indicate certain multiples of the sines and cosines of the hour angles, and of the successive multiples of the hour angles, θ, 2θ, 3θ, 4θ, the four orders being usually sufficient to give a satisfactory approximation. Such a method of representing a periodical phenomenon had the great advantage of being definite in its character, and of admitting of the precise comparison between various curves of the same nature, as well as of comparing an observed series of values with a series computed, for instance, from certain given physical data.

Mr. ABERCROMBY said that Mr. Bayard's questions really brought the whole question of the principles of averaging to the front. The nature of diurnal variation of pressure was such that it was always superimposed on larger general changes. In the Tropics the general changes might be 0·1 in. in a month, and the diurnal as much as 0·12 in. between 10 a.m. and 4 p.m.; while at Valencia, the general changes might be 2 ins. in a month and the greatest amount of diurnal variation only 0·03 in. He had drawn on a diagram the general changes for every day of January 1877—the month for which Mr. Bayard's mean curve was constructed,—and it was obvious that the geometrical sum of all these thirty-one curves would not be approximately a straight line. Hence Mr. Bayard's curve represented the diurnal variation superimposed on an irregular curve of unbalanced general changes, and no deduction could be made from it as to the nature of the diurnal variation for the month in question. The greater part of the irregularity was caused by two very pronounced cyclones, and if they were left out in the means for the month a much better result would be obtained. The difficulty of arriving at diurnal variation was still further increased by the tendency of cyclones to come in from the Atlantic during the night; for on fifteen days in that month the mercury was falling from midnight till 5 or 6 a.m. and rising on only ten occasions.

Mr. SYMONS thought it was a pity to attempt to get out the diurnal range of the barometer from such a small number of years. Mr. Dowson's observations only extended over four years, but he considered that for the British Islands not less than twelve years' observations should be utilised in order to obtain a trustworthy curve.

Mr. **Curtis** said that without doubt, as Mr. Abercromby had pointed out, the real cause of the abnormal character of Mr. Bayard's mean barometer curve for January 1877 was the great unsteadiness of the barometer during that period. The large difference between the mean value for midnight and that for 1 a.m. was accounted for by the fact that while at the commencement of January 1st the barometer was very low, it had risen a great deal by the following midnight; and so the low reading at the beginning of the day was set against a comparatively high one at the close of it. It was clear that for the purpose of such curves it was necessary to calculate the mean for 0 hours as well as for 24 hours. Apparently there were some analogous cases shown on Mr. Dowson's diagram, which would be improved if the mean for the beginning of the day were calculated, and still further improved if the periodic were disengaged from the non-periodic variations by the application of the formula to which Mr. Bayard had referred.

Mr. **Archibald** said that Ekholm's method seemed to be the best for obtaining diurnal variation from short periods of observation. He considered the series under discussion too short to form a proper diurnal curve. The whole question of diurnal variation had already been thoroughly threshed out from longer series, and very little really gleaned as to its precise cause or causes. He thought it might be more useful if the diurnal period were sometimes subtracted and the remainder exposed for inquiry.

Mr. C. **Harding** said that when examining the observations made at Kerguelen Island by the Rev. S. J. Perry, he found that the elimination of certain exceptional days altogether altered the form of the diurnal curve. There was no doubt that in the Tropics a month's observations afforded material from which to deduce a satisfactory diurnal curve, but in higher latitudes a much longer series was required. Some years since he thoroughly studied Bessel's formula, and it was much easier to understand than many meteorologists evidently thought, and the working of the constants could be rendered very simple. When doing a large amount of this work he had developed a form which greatly facilitated the calculations and also effected a considerable saving of time.

THE CLIMATE OF FIJI.

Results of Observations taken at Delanasau, Bua,

During the Five Years ending December 31, 1885,

WITH A

SUMMARY OF RESULTS FOR TEN YEARS PREVIOUS.

By R. L. HOLMES, F.R.Met.Soc.

[Read November 17, 1886].

To my two previous five-yearly reports on the Climate of Fiji[1] I now offer to the Society a third, embracing a similar term of five years, forming thus an unbroken series of fifteen consecutive years.

In the former papers I have fully described the position of the station and the quality of the instruments in use, it is therefore unnecessary to repeat those particulars any further than to give a few explanatory notes thereon.

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[1] *Quarterly Journal*, Vol. III. p. 260, and Vol. VII. p. 222.)

There has been no change in the position of the louvre-boarded screen containing the thermometers and hygrometer, which is suspended, as heretofore, under the verandah facing north-west. The galvanised iron roofing of the verandah is protected from direct sunshine by a thick covering of evergreen climbing plants. The barometer is suspended on the wall inside the dwelling-house, within which no fires are ever lit, and the doors and windows in the daytime are always open and at night partly so.

The hours of observation have been rigidly adhered to throughout, viz. 9 a.m. daily for all instruments, and at 3 p.m. an additional reading of the barometer; the remarks column being filled in every night.

Delanasau—the native name of the homestead—lies in lat. 16°38′ S, long. 178°37′ E (by chart); it is about 70 ft. above the sea-level, and is distant from the sea one mile, on the north side of Vanua levu, the second largest island in the group.

Table I. contains the monthly and yearly reduced means of the barometer during the five years 1881-1885. Similar results for 1879 and 1880 appeared in a previous report. The difference between the highest and

TABLE I.

Atmospheric Pressure, Mean of 9 a.m. and 3 p.m. Readings.

Months.	1881.	1882.	1883.	1884.	1885.	Mean.	9 a.m. readings[1] above 3 p.m.
	In.	In.	In.	In.	In.	In.	In.
January	29·750	29·728	29·767	29·807	29·737	29·758	0·058
February	29·762	29·844	29·756	29·804	29·808	29·795	0·063
March	29·838	29·811	29·793	29·876	29·793	29·822	0·068
April	29·901	29·911	29·886	29·898	29·835	29·886	0·077
May	29·916	29·911	29·931	29·947	29·960	29·933	0·081
June	29·943	29·956	29·955	29·980	29·995	29·966	0·078
July	29·944	29·956	29·969	29·974	29·971	29·963	0·081
August	29·975	29·974	29·984	29·966	29·965	29·973	0·079
September	29·971	29·961	29·967	29·986	30·017	29·980	0·081
October	29·939	29·961	29·945	29·966	30·014	29·965	0·072
November	29·868	29·870	29·872	29·883	29·921	29·883	0·068
December	29·777	29·765	29·791	29·824	29·866	29·804	0·060
Year	29·882	29·887	29·884	29·909	29·907	29·894	0·072

Mean for 1879, 29·911 ins. Mean for 1880, 29·893 ins. Mean for seven years, 29·896 ins.

[1] The month of highest average 9 a.m. pressure above that at 3 p.m. was May 1883, viz. 0·088 in.; the month of lowest average January 1882, viz. 0·047 in.

The following are the only instances in those five years in which the 3 p.m. readings were equal to, or exceeded those of 9 a.m.:—

			Ins.		Ins.
1881	February 3rd	9 a.m.	29·642	3 p.m.	29·652
1882	February 7th	„	29·687	„	29·695
1883	January 13th	„	29·493	„	29·512
1885	February 24th..........	„	29·867	„	29·867

lowest yearly averages is only 0·029 in., or from 29·911 ins. in 1879, to 29·882 ins. in 1881; the mean for the seven years, viz. 29·896 ins., may therefore be taken as a close approximation to the average of a long term of years.

The extreme range of pressure in the five years, viz. 0·904 in. is noteworthy, and shows that great storms, which would have produced diminished pressure and extended range, were absent.

All barometric observations, unless otherwise stated, have been corrected for index error, and reduced to 32° at mean sea-level.

Table II. gives the principal results of fifteen years' daily observations on the temperature of the air in the shade. The averages for the three terms of five years each agree in a most remarkable manner. It may, however, I think be safely assumed, owing to the somewhat unfavourable position of the thermometers, that 1° less, or say 78°, would more nearly represent the true mean annual temperature. As regards index errors I am uncertain, not having been able to compare the instruments with a standard, or to verify them, since leaving New Zealand about sixteen years ago. In the cloudier and moister districts of Fiji, the results will vary accordingly; and a lower mean temperature with reduced daily range will prevail. The total range of temperature in the shade in fifteen years was 42°·8, or from 98°·6 to 56°·8.

TABLE II.—TEMPERATURE OF AIR IN SHADE, 1881–1885.

Month.	Mean.	Extremes.		Range.	
		Max.	Min.	Mean Daily.	Mean Monthly.
	°	°	°	°	°
January	81·1	95·8	69·4	13·4	23·3
February	80·6	93·8	70·5	12·9	21·3
March	80·5	94·3	68·2	13·3	22·6
April	80·3	93·6	67·2	15·3	23·4
May	79·6	93·0	63·0	15·7	26·2
June	77·2	92·1	58·0	17·2	29·1
July	76·5	90·7	58·2	16·1	27·8
August	76·5	92·8	58·0	15·8	28·6
September	77·8	93·3	59·5	17·3	29·4
October	78·9	95·5	61·0	18·0	29·4
November	80·5	96·6	63·0	15·7	27·2
December	81·0	95·8	66·8	14·6	24·7
5 years.					
1881—1885	79·2	96·6	58·0	15·4	26·1
1876—1880	79·3	98·6	56·3	15·5	26·1
1871—1875	79·1	97·7	58·5	15·6	26·1
15 years. 1871—1885	79·2	98·6	56·3	15·5	26·1

In 1888, on the four quarter days, I noted the temperature of a perennial spring, near its outflow, and in the shade, with the following results:—

March 21st	79°·0	September 21st ...	76°·5
June 21st	76°·8	December 21st ...	78°·4

the mean, 77°·7, is probably a very close approximation to the mean annual temperature of air in shade.

Table III. gives each month's rainfall during the five years, with the number of days on which rain fell; and Table IV. summarises the results of the three periods of five years each. Since 1880 the yearly decrease in the rainfall has been very marked; in 1880 the total fall amounted to 115·61 ins.,

TABLE III.—RAINFALL, 1881—1885.

Month.	Rainfall.						No. of Rainy Days.					
	1881.	1882.	1883.	1884.	1885.	Mean.	1881.	1882.	1883.	1884.	1885.	Mean.
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.						
January..	12·32	13·20	7·20	7·80	9·39	9·98	24	18	15	13	19	18
February	19·14	12·30	14·97	16·25	12·37	15·01	23	21	23	17	19	20
March ..	15·08	24·48	12·08	10·54	7·83	14·00	20	23	19	24	18	21
April	3·79	4·88	6·13	5·27	2·74	4·56	9	13	15	10	14	12
May	3·45	13·67	5·27	1·15	0·98	4·91	12	19	8	6	8	11
June	0·47	1·40	3·88	0·31	3·30	1·87	5	7	8	6	12	8
July	3·91	4·69	4·57	0·53	1·10	2·96	10	11	8	3	7	8
August ..	3·67	1·55	1·63	1·33	4·36	2·51	14	7	8	6	15	10
September	2·26	1·12	0·36	3·31	0·94	1·60	10	10	3	9	10	8
October ..	2·38	2·76	8·06	3·88	2·98	4·01	10	7	12	4	4	7
November	19·96	6·39	4·65	10·32	2·37	8·74	20	15	17	13	9	15
December	17·33	11·04	13·01	1·84	10·20	10·68	19	13	14	9	18	15
Year ..	103·76	97·48	81·81	62·53	58·56	80·83	176	164	150	120	153	153

Greatest fall in 24 hours—

	Ins.
In 1881....................	8·10 on Dec. 31st
„ 1882....................	4·01 „ March 9th
„ 1883....................	7·46 „ Dec. 27th
„ 1884....................	5·24 „ Feb. 6th
„ 1885....................	2·88 „ Oct. 16th

TABLE IV.—AVERAGE RAINFALL IN FIVE YEARLY PERIODS, 1871—1885.

Months.	Rainfall.				No. of Rainy Days.			
	1871–75.	1876–80.	1881–85.	1871—1885.	1871–75.	1876–80.	1881–85.	1871—1885.
	Ins.	Ins.	Ins.	Ins.				
January	25·69	22·90	9·98	19·52	23	20	18	20
February	16·76	16·05	15·01	15·94	20	19	20	20
March	25·74	13·76	14·00	17·83	22	18	21	20
April	11·25	6·87	4·56	7·56	18	16	12	15
May	5·78	3·72	4·91	4·80	11	8	11	10
June	3·17	1·56	1·87	2·20	7	6	8	7
July	1·64	2·46	2·96	2·35	5	7	8	7
August	5·69	1·92	2·51	3·38	10	7	10	9
September	4·86	1·79	1·60	2·75	12	6	8	9
October	7·16	5·74	4·01	5·64	13	10	7	10
November	9·08	5·68	8·74	7·17	11	10	15	12
December	9·33	7·44	10·68	9·15	18	13	15	15
Annual Average	126·15	89·89	80·83	98·29	170	140	153	154

in 1885 it was only 58·56 ins., the average annual decrease for the five years was thus 11·41 ins., yet owing to the heavy precipitation in former years, the mean for the fifteen years stands well up yet, viz. 98·29 ins. on 154 days. From this it appears that the very dry seasons that have been experienced far and wide, and particularly in parts of Australia, Ceylon, the West Indies, &c. during the last three years or so, have also prevailed over a large portion of Fiji. The average rainfall during the last five years, viz. 80·83 ins., or even the much lower average for the past three years, viz. 67·63 ins., will perhaps appear ample for all requirements; but it must be borne in mind that the bulk of the rain falls during the so-called "wet season"—from December to March,—and that the high temperature all the year round, with prevailing bright sunshine and strong winds during so many months, causes enormous evaporation from the soil, &c. In a former paper I spoke of a really severe drought that extended from May 1877 to September 1878, seventeen months, during which only 52·42 ins. of rain fell; but with that one exception, as an old Australian, I ever hesitate to use the term "drought" even during the late dry seasons here. For, except in closely-fed paddocks and exposed hillsides, there is even in the driest time abundance of wholesome green feed for stock, and only a few of the very small streams ever cease to run. Nevertheless, the crops have suffered much of late years, at intervals, in some districts, from insufficient moisture, and difficulties have been experienced in most field work during the half-years ending in October or November. The few tea and coffee plantations in the group are mostly situated high up among the forest covered hills, and are always well supplied with rain. But some of the sugar mills lie on low levels, and in some districts irrigation for the cane fields is thought advisable if such dry seasons continue. Probably no crop here suffers so much from insufficient moisture as do cocoanut palms, and the yield of copra from them has of late years been much reduced. As has been so often pointed out, the amount of rainfall in different parts of Fiji varies exceedingly in some years; the northern half of the two largest islands, and the small islands, including the Yasawa group and most of Lau, are as a rule much drier than the south and south-east parts of Viti-levu and Vanua-levu, and Taviuni: on the latter island, which is the third largest in the group, on the hills near its southern extremity, 2½ miles from the sea and 564 ft. above sea-level, Mr. James Newall registered, in 1876, 248·07 ins. of rain on 236 days; and in 1877, 251·57 ins. on 228 days: these are, I believe, the highest amounts recorded in Fiji up to the present time. On the high hills of Taviuni-south the strong South-east Tradewinds strike, vapour-laden from the boundless South Pacific Ocean.

The only records of rain falling in quantity in very brief intervals of time worthy of mention in this district are the following:—

	Ins.
1881, November 26th, in 1 hr. 15 mins.	3·25
1882, December 10th, in 45 mins.	1·10
1885, February 28th, in 1 hr. 15 mins.	1·82
1885, March 8th, in 30 mins.	0·86

For similar statistics for the years 1871-1880 see previous reports. The rainfall in other parts of Fiji is given in Table V.

TABLE V.—Rainfall in other Parts of Fiji.[1]

Observer.	Island.	Above Sea-Level.	Distance from Sea.	1881.	1882.	1883.	1884.	1885.
		Ft.	Mls.	Ins.	Ins.	Ins.	Ins.	Ins.
J. D. W. Vaughan, F.R.Met.Soc., Suva (capital)	Viti levu, S.E.	200	..	..	..	..	90·80	74·50
G. H. Lee, 1885 A. Amos, 1881, 82, 83, Waimanu, Rewa	Ditto, S.E.	..	..	152·77	114·52	123·14	..	83·59
H. Baillie, Tarana, Serua	Ditto, S.	..	..	133·72	138·04	113·22	86·83	..
R. F. Harris, Nadi	Ditto, W.	..	..	..	..	55·12	39·74	46·78
R. B. Leefe, Ellington	Ditto, N.	100	..	..	..	91·37	62·76	49·36
W. Thomson, Savusavu	Vanua levu, S.	100	½	..	..	..	101·45	121·01
B. Ganly, for D. Wilkinson & Co., Kadi, Bua	Ditto, W.	700	5	123·71	120·94	93·43	69·35	60·34
F. R. Spaeth, Vatuboro, Dreketi	Ditto, N.	70	4	..	..	..	..	67·69
J. Newall, Wai ni Gere, Vuna	Taviuni, S.W.	30	0	99·61	111·35	154·91	108·45	..
A. J. Stephens, Alpha	Ditto, Central	1000	..	..	110·55	183·11	107·31	122·22
J. M. Borron	Mango	40	..	..	..	76·44	43·76	43·02
F. L. Langdale	Wakaia	..	..	104·52	60·53	70·77	70·31	46·74

[1] To the gentlemen whose names are attached we are indebted for the above statistics; they are all planters except Mr. Vaughan; there are no Government Meteorological Stations. The decrease in the rainfall of late years is very discernible, and the heavier precipitation on the S and SE coasts of the larger islands, that are exposed to the moisture-laden SE Trade winds, is also very marked.

Observations on solar and terrestrial radiation have been neglected during the last five years, as one of the instruments was broken by cats, and could not be easily replaced. I repeat one year's results of observations taken daily in 1875, viz. mean of all maxima in sun's rays (black-bulb exposed) 122°·1; absolute maximum 144°·4, on November 26th; mean of all minima on grass (spirit) 68°·2; absolute minimum 51°·8, on the night of August 20th. But during the intensely hot season at the close of 1877 the black-bulb registered 172°·0, 162°·0 and 165°·7, on December 23rd, 24th and 25th respectively.

The average number of hours *per diem* of clear sunshine were: in 1878, 7 hrs. 42 mins.; in 1879, 7 hrs. 15 mins.; in 1880, 6 hrs. 27 mins. In those three years the average number of days that were overcast throughout was 7·3.

The storms that occurred during the five years 1881-1885 were few in number, and none of them were very severe or very destructive; only seven are worthy of mention, viz. 2 in 1881, 3 in 1883, and 2 in 1884; they all took place in the "wet-seasons," or between December and March. They may be very briefly alluded to thus:—1881, February 2nd, a hard gale from East-north-east to North. At Baulailai, a plantation ten miles to westward of this, wind began from the same direction; when North-east it fell calm for half-an-hour, then recommenced with equal force from South-west. This cyclone had a diameter of about 150 miles; it was not felt in Viti levu west. At Levuka some vessels were blown ashore, but no loss of life occurred. The lowest reading of barometer here was 29·318 ins. at 9 p.m. This gale took place in the centre of a very wet and disturbed period; more or less rain fell on thirty-one days in succession, equal to 26·30 ins.

1881, December 31st.—A similar gale from East to North-west by the North, remarkable also for heavy rainfall, viz. 8·10 ins. in twenty-four hours; barometer minimum 29·447 ins. at 3 p.m.

1883, January 12th.—We were near the western edge of a cyclone that extended eastwards as far as the Friendly Islands; here the wind blew hardest at 3 p.m. from South, veering to South-west. Barometer minimum 29·448 ins. On Taviuni and in eastern Fiji generally much damage was done to plantations and houses.

1883, February 24th.—Gale from North-west veering to West with heavy rain, but no thunder or lightning. In Levuka serious damage was caused by this storm on shore and on the sea; a half-caste woman and her child were killed by the overturning of a house. It was spoken of there as the hardest blow since the 1871 hurricane. Here the lowest reading of the barometer was 29·384 ins. at 3 p.m.

1883, December 27th.—Violent squalls from North-east with heavy rain—7·46 ins. in twenty-four hours.

1884, January 9th gave us our first experience of a rotatory gale, the centre or vortex of which passed here. The wind blew furiously till 4 p.m. from East to North-east; then one hour's lull, when the wind recommenced with equal violence from South-west, dying out in the night. Barometer minimum 29·235 ins. at 4 p.m. Not much damage done anywhere so far as I could ascertain. During the disturbed period from 7th to the 10th 6 ins. of rain fell.

1884, February 6th-8th.—A very wet and unsettled period; overcast and gloomy in the extreme. On the 7th and 8th very stormy from North-east, North and North-west. Rainfall in forty-eight hours 9·73 ins. As on similar occasions previously, no thunder was heard during the prevalence of the blow. Barometer minimum 29·471 ins. at 3 p.m. on the 8th.

In a previous report I mentioned three occasions of hailstones having fallen in Fiji since 1865, before which date no records are available. The occurrence is so rare that in most districts the natives know nothing of snow or ice in any form. To the above list I have now to add one more instance of a hailstorm, that occurred on September 24th, 1884, on Batiki, a small island to the east of Ovalau and Levuka. The *Fiji Times* in mentioning it says, "the natives described the stones to have been as large as hens' eggs," a statement regarding size that, remembering the Fijians' aptitude for exaggeration, may be taken with the proverbial "grain of salt."

Earthquakes, or rather earth tremors, continue to be not uncommon, but, as a rule, they are very slight and insignificant, and quite harmless. The heaviest "shakes" in this district during the past five years occurred on January 22nd, 1884, at 8 and 9.30 p.m.

The red glow in the sky before sunrise and after sunset that attracted so much attention in almost all parts of the world, and which was so voluminously written about and described, and generally attributed to cosmic dust thrown into the higher atmosphere by the Krakatoa eruption, was particularly visible and attractive here for a long time. There are very frequent allusions to it in my diary, extending from early in November 1883 to April 26th, 1884; which period embraces the whole of our "wet season," when often for many days together the brilliant display was concealed by clouds. But on cloudless, or almost cloudless evenings, the bright rose-coloured glow suffusing the whole sky and earth from west to east attracted our admiration, and it often extended for fully an hour after sunset.

HURRICANE IN FIJI.

March 3rd-4th, 1886.

By ROBERT LANGLEY HOLMES, F.R.Met.Soc.

(Plate I.)

[Read December 15th, 1886.]

A very severe hurricane occurred in Fiji on March 3rd and 4th, 1886, causing the loss of many lives and the destruction of much valuable property. It ranks first in importance of all storms experienced in the group for very many years. I have, therefore, spent some time in carefully collecting, and especially in verifying accounts from the districts over which it passed, and these particulars I have now much pleasure in laying before the Society.

To record the tropical storms that have occurred in Fiji since my arrival in the group in 1869 has fortunately been an easy task. During the last sixteen years, seventeen storms have been registered here; of these, one, that of March 1871, was of the first order, five were of the second, and eleven of the third order. The hurricane of March 20th-21st, 1871, was severely felt throughout the group, but the vortex passed in the extreme west near Nadi. Of the five storms of the second class, those of December 30th, 1873, and January 12th, 1883, were most severe on the east side of the group, on Taviuni especially; those of January 8th, 1875, and February 24th, 1883, passed through the centre of the group, and were most destructive in Levuka; and that of December 11th, 1879, passed over the west end of Viti Levu. Previous to 1870 only two great cyclones had occurred in Fiji since Europeans began to arrive, viz. one in March 1856, the other in March 1866. The one now under consideration is, therefore, the fourth great hurricane recorded in Fiji during at least forty years.

Mercurial barometers are unfortunately very scarce in Fiji, I know of only two besides my own, and they are both in Suva, in the possession of Mr. J. D. W. Vaughan, F.R.Met.Soc. Aneroids, on the other hand, are very plentiful, and as a rule they are good instruments, carefully looked after, being highly prized as storm indicators. I have taken pains to ascertain what reliance can be placed on the instruments that gave such remarkably low readings during the hurricane, and with satisfactory results; the index errors of the principal ones seem to have been ascertained previous to, or immediately after the blow, by comparison with Mr. Vaughan's barometers, the index errors of which are known.

I am well aware that the Council of this Society has decided generally not to accept readings of aneroids, as being too liable to error from causes inseparable from their construction; and in this I heartily concur; but in newly settled countries like Fiji scientific accuracy cannot always be expected. Throughout this Paper my own readings of the mercurial barometer are invariably corrected for index error and reduced to 32° at mean sea-level, whilst the aneroid readings elsewhere have been corrected so far as it was possible to ascertain particulars. Fortunately most of the observations were made very close to sea-level, therefore requiring only slight correction for elevation. The remarkably low pressures recorded by the instruments along the central track of the hurricane render these remarks advisable. There are no particulars forthcoming showing the amount of rainfall in the vortex, but it was described as excessive beyond all previous experience. There were no anemometers to measure the velocity of the wind.

The accompanying Table gives the most trustworthy records available of the lowest pressure of the atmosphere at various stations, with the latitude and longitude (by chart), the names of the observers, and the hours of observation. On the map (Plate I.) a line has been drawn showing approximately the track of the centre of the hurricane in its passage through the group. The rate of the onward course of the hurricane has been well determined over a long distance, viz. from Wallis Island to Vuna, a distance of 320 miles, which was traversed by the whole body of the storm in thirty-two hours, or an average of ten miles per hour; and from Vuna to near Levuka 86 miles in six hours, or 14⅓ miles per hour; giving an average speed over 406 miles of 14¾ miles per hour.

The diameter of the central calm was about 25 or 26 miles, as it took about two hours to pass over one station, Selia Levu in south-east Taviuni.

I can only name two barometric gradients that are reliable: one from here (Delanasau) to Buca (Mbutha) Bay, a distance of 80 miles, almost due East and West. Simultaneous readings of my barometer with the mean of two corrected aneroids on board the *ss. Suva*, Captain G. Crawshaw, at 1.30 a.m. on March 4th, were:—Delanasau 28·894 ins., Buca Bay 27·68 ins., difference 1·264 in. in 80 miles, or 63¼ miles to one inch of mercury. Secondly, from here to Vuna at 3 a.m.; the lowest reading at both stations. Vuna lies about east-south-east, distant 88 miles from here, at right angles to the track of the hurricane; namely, Delanasau 28·868 ins., Vuna 27·54 ins., difference 1·328 in. in 83 miles, or 62½ miles to one inch of mercury. Vuna lay much nearer the centre of the vortex than did Buca Bay; in the former place the calm lasted one hour, in the latter twenty to thirty minutes. Probably steeper gradients than the above might have been recorded had there been any intermediate stations. A third and much steeper gradient, from Levuka eastward, is given on the supposition that the pressure in the centre of vortex was the same as that at Vuna, and that that centre was 50 miles east of the town, on the sea, but only about ten miles east of Gau (Angau), where the calm was felt for a short time. At 9 a.m. the atmospheric pressure in Levuka was 28·50 ins., at the vortex 27·54 ins., giving a difference of 0·96 in. in 50 miles, equal to 52 miles to one inch of mercury.

I will briefly describe what occurred at this station (Delanasau), and show how far the hurricane affected us at a distance of about 80 miles west of the track of the centre. For about 60 miles east and west of the centre great havoc was done; for other 40 miles serious injury was still caused by wind and flood. At 100 miles each side the damage was slight; and at 150 miles only an ordinary gale was reported. The total diameter of the storm, supposing it to have been circular, may be therefore set down at 300 to 350 miles.

February, the month preceding the hurricane, was remarkable throughout the group for great heat, prevailing sunshine—very unseasonable—and light rainfall; thus only 3·86 ins. of rain fell here, compared to 15·94 ins. the mean for the same month in previous fifteen years; and at Bua, 14 miles west of this, only 0·91 in. was registered. March 1st was bright and hot, the maximum temperature in the shade being 94°; barometer 9 a.m., 29·726 ins.; 3 p.m., 29·663 ins., wind South-east, moderate, with a shower at 3 p.m.; so far all looked fair and in order. March 2nd, barometer 9 a.m., 29·666 ins.; 3 p.m., 29·556 ins., highest temperature 92°·3, wind South-east, strong and steady; evening overcast, squally, and ugly looking, but without thunder or lightning, which we always expect at the beginning of a great storm, but never during its continuance. March 3rd, barometer 9 a.m., 29·480 ins.; 3 p.m., 29·240 ins.; 6 p.m., 29·236 ins.; 9 p.m., 29·164 ins.; midnight, 28·974 ins. As this day—the 3rd—advanced, it became quite evident that a great storm was approaching from the North or North-east. Very light rain fell continuously, the wind increasing, and veering from South-east towards South. An invariable forerunner here of very rough weather was always sounding in our ears, for though the wind was nearly South, there came from the North a loud continuous roar of the surf breaking on the outer reef, here 20 miles off shore. As night closed in the wind increased to a hard gale from the South, with very heavy rain and most intense blackness, there being no moonlight as it was only two days before new moon. March 4th, barometer at 1 a.m. 28·914 ins.; 2 a.m., 28·884 ins.; 3 a.m., 28·868 ins. the lowest; at 4 a.m., 28·876 ins.; at 6 a.m., 28·944 ins. From midnight till near daylight the wind blew with hurricane force, veering from South to South-west. At 9 a.m. the barometer had risen to 29·088 ins.; at noon to 29·198 ins.; and at 3 p.m. to 29·296 ins., after which the rise was steadily maintained for many days; six inches of rain fell during the night of the storm: the temperature did not fall below 76° at any time. The 4th continued very stormy from South-west to West, with heavy rain in forenoon, lighter in the evening when the wind fell to a strong breeze only. In this neighbourhood there were only two vessels on the sea at anchor in the best positions they could find—one, a schooner, was dashed to pieces, the other, a cutter, was blown ashore, but was afterwards recovered and repaired. No lives were lost in either case.

Such was our experience here; the damage done was considerable, but insignificant when compared with what many others suffered.

The point furthest north from which accounts were afterwards received, showing the position of the hurricane in its passage to the southward, is Uea, or Wallis Island, in lat. 13° 24′ S., long. 176° 10′ W. It lies about 280 miles north-east of the Fiji group, and is inhabited chiefly by blacks with two or three white settlers. The storm did great damage in overthrowing houses and trees and destroying crops, but the vortex must have passed a considerable distance to north-west of it, and very much nearer to Fotuna and Alofa, islands from whence no accounts have yet been received; they lie 122 miles south-west by west of Uea. From Uea the hurricane continued its course south-south-west to Fiji, striking the north-east corner of the group, the vortex passing down Somo-somo Straits and the storm extending on to Taviuni on the east, and Rabi (Rambi) and part of Vanua Levu on the west. Rabi is a very fine fertile island owned by Captain John Hill & Co., who have large plantations on it including about 600 acres of cocoanuts. The homestead lies (or did lie) on the west side of the island, beautifully situated, and very complete with its numerous surrounding buildings for manufacturing copra, fibre, &c., labourers' houses, stores, &c. From a correspondent on the spot, we learn through the *Fiji Times* that on March 1st the aneroid fell from 30·00 ins. to 29·80 ins., wind North-east; a heavy swell set in from north on March 2nd, the swell increased considerably, wind veering to East and South-east, aneroid 29·70 ins. March 3rd opened with a leaden sky, violent squalls of wind and rain; glass falling rapidly, sometimes in jerks, sometimes steadily; at noon it registered 29·50 ins., wind South-south-east in terrific squalls, and a deluge of rain; and the swell increased to an unprecedented height, rolling in in literal mountains, with a cross-swell from north-west. At sundown, aneroid 29·00 ins., at 10.30 p.m. 28·20 ins., the hurricane increasing meanwhile. The glass afterwards fell, according to Captain Hill, to 27·80 ins., the limit of the instrument.

The buildings occupied by Captain Hill and his family stood about 300 yards from the sea, at an elevation of about 100 feet; these were demolished in the last squall of the South-east wind, the occupants having only vacated the strongest house about one minute before it fell. The whole family, by crawling underneath the ruins of the house, found safety from the falling timbers and other missiles, but lay there exposed to the drenching rain and miserably cold until daylight on the 4th, by which time the wind force had lessened in some degree and the rain was not so heavy. The scene of desolation at dawn of day was indescribable, not a standing building to be seen; the spot where the Coolie lines, the overseers' houses, factories, stores, &c. had been, was swept clean by the sea, and the whole flat was covered with uprooted trees, timber, sheets of iron, bags of flour, rice and sugar, cocoanut fibre, tanks, broken boats, punts, &c. in one chaotic mass. The best shelter Captain Hill could improvise for himself and family, in all ten persons, was in the shape of two 500 gallon iron watertanks; and the labourers crawled under the floors of the fallen dwelling-houses until the weather permitted them to erect temporary shelter.

About 16 miles south-west of Rabi lies Buca (Mbutha) Bay, a deep indentation in Vanua Levu, protected from Easterly winds by the small island of Kioa. In the bay lay the *ss. Suva* during the blow, and Captain G. Crawshaw, who commanded it, has sent me the following particulars of the hurricane as he experienced it there. The steamer anchored at Vuna early on March 2nd; very thick threatening weather, aneroid falling, at 8 a.m. 29·75 ins. Early in the afternoon Captain Crawshaw picked up anchor, and ran for shelter to Buca Bay. Anchored at 5 p.m., aneroid 29·68 ins.; at 10 p.m. 29·69 ins. (?). March 3rd, heavy squalls from east, and thick rainy weather. Aneroid at 7 a.m. 29·57 ins.; 10 a.m. 29·51 ins.; 11 a.m. 29·49 ins.; 2.30 p.m. 29·32 ins.; 4·30 p.m. 29·22 ins., wind increasing to strong easterly gale with fierce squalls. At 6 p.m. aneroid 29·15 ins.; 8 p.m. 29·00 ins.; 9.30 p.m. 28·85 ins.; 10·30 p.m. 28·68 ins. At midnight the squalls became heavier: aneroid became jumpy, but still falling. At 0·20 a.m. on the 4th it fell suddenly to 27·62 ins.; and at 1.30 a.m. it reached its lowest point, 27·57 ins., when after a terrific squall the wind fell to almost a calm for nearly half-an-hour, then veering by South to South-west it gradually increased to as great violence as before, with heavy rain. At 2.20 a.m. the aneroid stood at 27·68 ins., wind West; at 8 a.m. 28·90 ins., heavy weather still. At 10 a.m. the squalls slightly decreased; and at 2.30 p.m. the weather had sensibly improved, but still blowing hard, aneroid 29·25 ins., wind West. At 10 p.m. 29·38 ins. March 5th, wind North-west, 4 a.m. aneroid 29·60 ins., and at 8 a.m. weighed anchor and proceeded to Rabi. Concerning the instruments Captain Crawshaw has sent me the following:—"The barometers I had on board were aneroids, one registered 27·64 ins. the other 27·57 ins.; the latter was compared with standard at Suva, and correction found to be 0·06 in. to add." The lowest reading, as above, with this correction may be taken therefore as 27·63 ins.

We must now cross over Somo-somo Straits to Taviuni, a large and very fertile island. On the south-west end lies Vuna township, distant from Buca Bay about 22 miles south by east. At Vuna there is a considerable population; a large sugar mill with its attendant village of houses of all kinds, where the Wesleyan Missionary and the Stipendiary Magistrate have their headquarters, also planters' homesteads, hotel, stores, &c. The destruction here was very complete: I quote the *Fiji Times*:—

> "Vuna is completely wrecked; the Mission house (a stone building) is down; Dr. Brower's house is levelled: a heap of stones alone marks the site of where Miller's store stood; the 'Vuna hotel' is scattered in fragments far and wide."

(The owner of the hotel, Mr. John Rosler, sustained fatal injuries by the fall of his house, whereof he died three days later.) "MacConnel's store is unroofed, and has two feet of sand in it. Of Tarte's store the roof alone is visible, the walls having collapsed; Holmhurst mill is partially unroofed, the dwelling-house and almost all the buildings on the estate are down. The sea has washed away the beach road, and the large stone wharf has been swept away. The local report is that it had been blowing a heavy gale from South and South-east all day on the 3rd, which increased at night with a constantly falling glass, till at 3 a.m. on the 4th the barometer stood at 27·54 ins., a reading unheard of before. There was then a lull which steadied to a calm, the sky cleared, and the stars came out; this calm lasted for over an hour; suddenly it was dispelled by the shriek, the roar, and the rush of the wind as it burst on the place from the opposite quarter—the westward. This completed the utter wreck that had before begun, and then the sea swept in and carried away the debris or buried it feet deep in sand and shingle. The highest tide-line has thus been removed several huudred yards inland; the boats were carried far inshore. There are only five houses left standing, and these had to give shelter to all the inhabitants of the place." . . . . "Now Messrs. MacConnel and Tarte are digging their goods out of what appears to be a century-old beach. The latter found his safe, weighing over 5 cwt., 50 yards from its usual position, and the site where the hotel once stood is a fine tract of smooth sea sand." . . . . "Up coast all the native towns have been totally destroyed."

The *Fiji Times* then describes the fate of the various plantations on the west side of the island; many places were utterly devastated, and on some of the plantations 25 per cent. of the old cocoanut trees were destroyed. At "Alpha," the fine tea estate of Mr. J. E. Mason, which lies 1,000 ft. above sea-level, every building was levelled, the crops destroyed, and one Coolie killed. The account in the *Fiji Times* concludes thus:—

> "From the coastline to the tops of the hills, it seems as if the country had been swept and devastated by fire. Nothing remains but bare sticks, and the blackened, torn, twisted relics of what constituted graceful and abundant foliage."

From Vuna the hurricane still continued its course in a south-south-west direction, the centre passing about 25 miles to the east of Koro, and approached within about half that distance of Nairai and Gau (Angau), its course then being nearly due south. Abreast of Gau it gradually curved to east of south, and passed out of the group between the islands of Matuku and Totoya. On Koro in some of the native villages not a house was left standing, and many vessels were wrecked: the lowlands were inundated by the storm-wave. The European planters on the island also suffered very severely, in houses blown down, boats wrecked, and crops destroyed. As stated above the centre of the storm passed ten or twelve miles to the east of Nairai and Gau; on the latter island the central calm is said to have been felt for a short time. The destruction on the eastern sides of those islands was excessive, and was caused mostly by the inrush of the storm-wave on the lowlands near the sea. At Vanuaso, on Gau, the wave was reported by the Hon. James Blyth, Commissioner of Native Affairs, in his *Official Report of the Storm*, to have "gone inland a distance of about 700 yards, and with a height, as it approached the shore, of about 18 ft. It came like a solid wall, clearing all things before it, and destroying everything within its reach." Later on Mr. D. Wilkinson, late Commissioner of Native Affairs, wrote me thus:—"It is quite true, it would appear, about the height of the cyclone wave; Mr. Blyth has measured it on both Nairai and Batiki, and found it was 81 ft., and in places went over 300 yards inland; beautiful little valleys that were fringed with cocoanut and bread-fruit trees are now covered thick with sand. The cocoanut trees are bare poles, and nothing but the stumps of bread-fruit trees now appear above the white sand to make the desolation complete. The depth of the storm-wave is clearly indicated by the debris left in the branches of trees, in some places as high as 30 ft. above high-water mark. The natives report that there were three successive waves, of which the first was much the greatest."

At Vannaso, a shark was killed among the houses, at another place a turtle and quantities of fish were found. The whole windward side of the island was wrecked, as it is undefended by a sea reef; six native villages were completely washed away, and the natives threatened with serious privation. At Malowai on this island (Gau) occurred a lamentable shipping disaster; the schooner *Ulu i Borutu* arrived in the beginning of the storm from Matuku with over sixty natives on board. Of these, twenty-three had landed in the boat when a squall obscured the vessel from sight, and she was never more seen; thirty-seven persons thus perished miserably in her; her mainmast only was afterwards found, it had been cut through with an axe.

The last places visited by the hurricane from which accounts have been received are the islands Matuku, Totoya, and Moala, in the south-east part of the group; it passed between the two first-named islands, distant from Gau about 75 miles. Similar destruction by storm-wave and wind were noted here by the Commissioner of Native Affairs, who visited the islands and supplied the natives with food in places where their own crops had been destroyed.

In Lau, as the east and south-east portion of the group is named, the islands Vanua-balavu, Mago (Mango), and Cicia (Thithia), lie parallel to the track of the hurricane, and about 60 miles east of the centre. There the wind began about East, and passed through North-east to North and North-west. At Mago the crops were laid flat, all labour houses on the Company's estate were overthrown, the wharf and landing stage were swept away, and the extensive sugar-mill buildings were much injured. From Cicia the report came—"Glass fell to 28·00 ins.; of twenty-seven substantial buildings on the estate only three remain sound, eighteen were blown flat, and two were washed away by the inbreaking of the sea." From Vanua-balavu the accounts received were almost similar.

Savusavu Bay, on south side of Vanua Levu, lies 50 miles to westward of the central track of the hurricane. There many vessels were wrecked, houses blown down, and plantations destroyed. On Mr. Harman's place, out of a plantation of 15,000 bananas, only about 600 remained standing.

Rewa river and district lies about 80 miles to westward of the track; here the great sugar-cane plantations suffered severely by the wind, in some parts more by floods.

Levuka, the former capital of Fiji, on the north-east of Ovalau, lies 50 or 55 miles west of the centre, and of course suffered very much. Fortunately the worst of the storm did not reach the place till after daylight on the 4th, so there was not the pitchy darkness to contend against, as at Vuna and further north. The town was described in the local press, after the storm, as presenting the appearance of having undergone a heavy bombardment; so many of the houses were knocked down, and scarcely one had escaped some injury. Passage through the streets during most of the day was attended with great risk from the number of missiles hurled about by the wind; the rain fell in heavy blinding torrents. In the neighbouring native villages scarcely a house was left standing, and the havoc among bread-fruit and cocoa-nut trees and bananas exceeded all previous record. The harbour, as usual when a storm threatens, was nearly deserted by shipping, nearly all the vessels having cleared out for a safer or more sheltered anchorage at the back of the island. Contrary to expectation the wind veered through South to South-west, and a great number of coasting craft, schooners, cutters, &c. were blown on shore or totally wrecked, with some loss of life. The ketch *Patience* broke from her moorings near Levuka, and ran foul of the cutter *Korotubu*; both tried to run before the gale with staysails only, these were at once blown to pieces, and both vessels were speedily wrecked on outlying reefs, and all lives lost except one man, Jas. Bourne, master of the cutter, a half-caste Samoan. When his boat sank, he jumped clear, and without support swam in an awfully tempestuous sea till the following morning, when he got ashore on the island of Mokodraga, about 20 miles north-north-east from where he was wrecked, having been over 18 hours in the water, inclusive of a short stay on an isolated wave-beaten patch of coral.

Suva, the capital of Fiji and seat of Government, situated 80 miles west of the centre of the cyclone, escaped with slight damage. In the harbour several small vessels, boats and punts were sunk, and the *ss. Clyde* parted her cables and drifted on to the wharf, where she sank. The barque *Bella Mary*, on her passage round from Suva to Levuka before the height of the gale, missed stays and ran on to the Mau reef near the mouth of the Navua river, and became a total wreck: all hands were saved.

A most interesting account is furnished by Captain Place, master of the schooner *Eastward Ho!* 45 tons, and a crew of six, of a long struggle with the elements. When caught by the hurricane, to the south-east of Taviuni, they cut away the mainmast to save foundering, but in falling it carried away the foremast and bowsprit, and the vessel drifted into the central calm where the most terrific seas prevailed; the deck was washed clean of everything including the compass. After three hours they passed out of the calm vortex, but for three days and nights were driven hither and thither. At last, with the aid of a short jury-mast and a small sail, they got clear into a calmer sea in the extreme south-east portion of the group. The lowest reading of the aneroid on board was, according to Captain Place, 27·54 ins. on the morning of the 4th, just previous to the lull. The total number of vessels wrecked during the hurricane according to the *Fiji Times* list was about 50; but many of these that were driven on shore on sandy beaches, or sunk in shallow water, were recovered and repaired. The list includes a barque and a steamer, all the rest were schooners, cutters, &c., that comprise the so-called Mosquito fleet of Fiji. According to the same well-informed source the total number of deaths resulting from the hurricane was about 64; these were mostly drowned, including thirty-seven Fijians who went down in the *Ulu i Borutu.* There were some Coolies and a very few Europeans, the rest were all natives of Fiji or Polynesians.

For most of the particulars contained in this account of the greatest hurricane recorded in Fiji I am indebted to the columns of the *Fiji Times*, and to the kindness of the following gentlemen, namely:—

T. H. Pritchard, Editor *Fiji Times.*
Captain R. Cocks, Harbour Master, Levuka.
Captain G. Crawshaw, Master *ss. Suva.*
Lieut. R. B. Leefe, late R.N.
D. Wilkinson, late Commissioner Native Affairs.
C. R. Swayne, Stipendiary Magistrate, Levuka; and others.

HURRICANE IN FIJI, MARCH 3RD–4TH, 1886.

LOWEST BAROMETER READINGS OBSERVED AT CERTAIN STATIONS.

Station.	Lat.	Long.	Date.	Hour.	Barometer.	Observer.
	° ′	° ′			Ins.	
Wallis Island[1]	12·24 S	176·10 W	2nd	7 p.m.	29·17	— Fraser, Mstr. Schooner *Taviuni*
Rabi[2]	16·28 S	179·58 E	3rd	About Midnight	27·80	Hon. John Hill, M.L.C.
Buca Bay[1]	16·40 S	179·50 E	4th	1.30 a.m.	27·63	Geo. Crawshaw, Master ss. *Suva*
Vuna, Taviuni[3]	16·57 S	179·52 E	4th	3 a.m.	27·54	Correspondent of *Fiji Times*
Selia levu, Taviuni[3]	16·58 S	179·58 E	4th	3.30 a.m.	27·67	A. V. Tempest
Nukudrau, Natewa Bay[1] ..	16·43 S	179·37 E	4th	2 a.m.	28·35	O. Broiderlow, Master Schooner *Ariel*
Nakama, Savusavu Bay[4] ..	16·45 S	179·20 E	4th	3 a.m.	28·50	Hon. Captain Barrack, M.L.C.
Levuka[4]	17·41 S	178·51 E	4th	9 a.m.	28·50	G. L. Griffiths, Proprietor *Fiji Times*
Suva[4]	18·8 S	178·22 E	4th	1 p.m.	29·00	J. D. W. Vaughan, F.R.Met.Soc.
Delanasau, Bua[5]	16·38 S	178·37 E	4th	3 a.m.	28·87	R. L. Holmes, F.R.Met.Soc.

[1] Observations taken on board ship.

[2] Elevation 100 feet above sea-level. The Rabi aneroid would probably have registered lower had the construction of the instrument admitted of its doing so.

[3] Slight elevation. [4] Elevation not recorded, but not much. [5] All corrections applied.

N.B.—No particulars were afforded in any case in regard to corrections for temperature. Unless the aneroids were "compensated" for temperature, it is safe to assume none were made, except in the case of [5].

Most of the aneroids were corrected for Index error by comparison with the Mercurial Barometer at Suva.

ON THE PROCEEDINGS OF THE

INTERNATIONAL CONGRESS OF HYDROLOGY AND CLIMATOLOGY AT BIARRITZ,

OCTOBER 1886.

BY G. J. SYMONS, F.R.S., F.R.MET.SOC., SECRETARY.

[Read December 15th, 1886.]

IN the summons for the Meeting of the Society June 1886 it was stated that—

"Arrangements are being made by the officers of several French Societies for holding an International Congress for discussing Papers upon Climatology, Mineral and Thermal Springs and allied subjects.

"A letter has been received from the Foreign Office transmitting copies of documents, and stating that the French Government is anxious that Members of Scientific Societies in this country should assist.

"The co-operation of the Royal Meteorological Society has also been specially asked by the President of the Congress, Dr. Durand-Fardel. The sittings at Biarritz will occupy the first week in October, and be followed by a three weeks tour to the principal watering places of Southern France."

Owing to the date fixed, no English medical men were able to attend, and from various causes only three Fellows of the Society were present, though several others had intended to go. Mr. Inwards and I were, however, the only two who adhered closely to the programme. It would be unjust to commence without recognising in the warmest terms the extreme courtesy and kindness shown to the English visitors, who were regarded as delegates of the Society. Indeed, the President, Dr. Durand-Fardel, desired me to convey to our Council his thanks for the aid and encouragement afforded by the publication of the notice convening the Congress, by the Society's exhibit of publications, and by the Paper communicated by our Assistant Secretary, Mr. Marriott. The exertions, not only of the President, but of the officers, were remarkable, and contributed largely to the great success of the Congress; where all worked so well, it is only just to recognise it, and especially to notice the efforts of Dr. Garrigou, M. O'Shea, M. Laugier and Dr. Fines.

I desire, on behalf of the English visitors, to record our thanks to the Préfets of the various departments, and to the Mayors and Municipalities of the various towns, for the almost endless succession of receptions and fêtes which no one who accompanied the excursion can ever forget. I think it right also to acknowledge the courtesy of all the French railway companies, not merely in reducing the fares, but in other arrangements for our comfort, which on a journey amounting to nearly 3,000 miles, are not to be ignored—a marked contrast to the uncouth treatment of the British Association by the English Railway Clearing House.

If at any time the International Congress should consent to visit England, we shall be quite unable to treat it as well as our French friends treated us.

The actual work of the Congress was commenced at a General Meeting in the Theatre at Biarritz, at 2 p.m. on October 1st. The building was decorated throughout with plants and garlands, and with the flags of most of the European nations and of course that of the United States. The platform was occupied by M. Nicolas, Conseiller d'Etat (representing the Minister of Commerce); M. Deffès, Préfet des Basses-Pyrénées; M. le Dr. Durand-Fardel (President of the Congress); M. O'Shea (President of the Biarritz Association); M. le Dr. Garrigou (General Secretary of the Congress); and a few others. The number of members present is unknown, but was probably 300 or 400.

It may be well here to dispose at once of the question of the numerical strength of the Congress. The total number of adherents was 1,056; but it must be remembered that some of these may be regarded as merely subscribers to the volume which will be published, giving *in extenso* the communications presented to, and read at, the Congress. Others, again, were residents in the South-east of France, unable to attend at Biarritz, but anxious to obtain the special information which was afforded to members of the Congress joining the excursions.

I regret that it is as yet impossible to give an approximately complete list of the numerous foreigners present—most of them delegates from the governments of the respective countries: the following is as nearly perfect as can be made in the absence of any official list:—

Austria.—M. Winternitz, Conseiller Impérial.

Belgium.—M. Gill; M. Lancaster (of the Royal Observatory, Brussels); M. Verhassel (President of the Pharmaceutical Soc. of Antwerp); Dr. Warcosuomm (President of the Roy. Academy, Brussels).

Brazil.—Dr. d' Azambuya.

Canada.—Dr. T. Sterry Hunt, F.R.S.; Dr. Huden.

Germany.—Dr. Kissch of Heidelberg.

Great Britain.—W. Bonallo, F.R.Met.Soc.; W. Dunn; R. Inwards, F.R.A.S., F.R.Met.Soc.; G. J. Symons, F.R.S., Sec.R.Met.Soc.

Holland.—Dr. Mess, of The Hague.

Hungary.—Dr. Kisch, of Buda-Pesth.

Italy.—Dr. Chiminelli.

Mexico.—Dr. F. Diaz; Dr. Covarrubias.

Monaco.—Dr. Collignon.

Portugal.—Prof. da Silva Amado; Dr. Tarrez.

Russia.—Dr. P. Soutschinsky, of St. Petersburg; Dr. Lubinoff.

Spain.—Dr. Silva; Dr. Fernandez; Dr. Diaz; M. Taboada.

Sweden.—Dr. Lamm.

Switzerland.—Dr. Vuillet, of Geneva.

United States.—Dr. Miller, of New York.

Dr. Durand-Fardel opened the proceedings with a very interesting and able address, from which, however, space prevents my quoting more than one paragraph:—

"It must be thoroughly understood that the solution of questions of climate can only be effected by co-operation. Isolated researches and fragmentary observations will not suffice, nor is it sufficient to bring together two observers or even two associations; country must join country, continent continent, for the whole globe is but their observatory and their laboratory. The honour and the ambition of the Biarritz Congress will have been to invite the *savans* of all countries to an assembly where they can each contribute to the foundation of a definite and universal science of climatology."

After several addresses had been delivered the Bureau was constituted as follows, and the meeting closed:—

President.	Dr. Durand-Fardel.
Secretary.	Dr. Garrigou.
Vice-Presidents.	M. Antoine d'Abbadie. Dr. Martineau. M. O'Shea.
Vice-Presidents (Foreign).	M. Chiminelli, of Florence. M. Kisch, of Prague. M. Soutschinsky, of St. Petersburg. M. Symons, of London. M. Taboada, of Madrid.

At 8 p.m. there was a reception at the Palais-Biarritz (formerly the Villa Eugénie), in order to facilitate personal intercourse between the members.

On October 2nd the sectional work began, three sections sitting at once. The sittings began at 8.30 a.m. and lasted till about noon; resuming at 2 p.m. and closing about 4 p.m. The list of papers as printed did not by any means include all that were read; but even as it stood the programme was sufficiently formidable, the number of memoirs for each section being respectively—

I. *Scientific Hydrology.*—Water analysis, micro-organisms, collection of mineral waters, geological influences, bathing apparatus, 34.

II. *Medical Hydrology.*—Physiological and medical questions, 40.

III. *Climatology, scientific and medical*, 35.

I can of course deal only with the third section, but for that it seems desirable to give the list *in extenso*:—

Bernis.	Climatograph.
Bonald.	Duality of Climates at Arcachon.
Buckler.	On the Climate of Biarritz.
Busin, Prof.	Mean Monthly and Mean Annual Temperature of Italy.
Dambier.	On the Climate of Pau. Results of Observations recorded at Pau during 30 years, by Miss York.
Hameaw, Dr.	Climate of Arcachon.
De Wecker, Dr.	Climatology of Biarritz and its Antiseptic Atmosphere.
Piche.	New Form of Meteorological Diagram. Budget of the Meteorological Commission of Pau. Vaporimeter.
Ducourhau, Dr.	Critical Study of Observations on the Climate of Pau.
Léon and Bouyer.	Climatology of the South-west.

Lübelsky.	On the Present Climate of Poland.
Peyroulet, Dr.	Meteorological Observations at Luchon.
Marriott.	On the Climatological Stations of the Royal Meteorological Society.
Estradère.	On the Sanitary State of Luchon during 15 years.
Doit-Lambron, Dr.	Climatology of Luchon.
Collignon, Dr.	Meteorological Observations in general.
Laserge.	Meteorological Observations made at Aragnouet.
Schrader.	Two Meteorological Questions.
Sparuzzi.	Scientific and Medical Climatology—Programme for Instruction in Meteorology.
Sébie.	Meteorology of Biarritz—The Climate and the Seashore of Biarritz.
Buys Ballot, Dr.	On the Establishment of a Meteorological Station at Biarritz, and its Utility to Navigation in the Golfe de Gascogne.
Dally, Dr.	On the Influence of Altitude.
Espina y Capo, Dr.	On the Medical Effects produced by Altitude.
Frémy, Dr.	On Phthisis and High Stations.
Lamm, Dr.	On the High Station of Yemtland in Sweden.
Chopinet, Dr.	Meteorological Observations during 10 years at St. Gaudens.
Crozats.	Meteorological Observations at Béziers.
Gandy, Dr.	On the Meteorology of Bagnères de Bigorre.
Lalesque, Dr.	The Winter Station at Arcachon—Physiological Effects of Residence in the Pine Forest of Arcachon.
Garrigou Lagrange.	On certain Phenomena of Evaporation and Condensation.—On Ascending and Descending Currents.—Observations made at the Observatory of Limoges.
Martinet, Dr.	Climatology of Banyuls-sur-Mer.
Martin, Dr.	Meteorological Observations at St. Jean de Luz.
Hedde, Dr.	Scientific and Medical Climatology of Hyères.
Pereira, Dr.	Influence of Lunar and Solar Attraction on the Level of Lake Némi.
Pitta, Dr.	Climatological Researches in Madeira.
Bonnafond, Dr.	Waterspouts.

Owing to the large number of these communications it was impossible to allow much time for discussion, and my notice must be limited to the only subjects discussed at any length.

The necessity for supervising and improving the quality of the climatological observations in the Pyrenean districts was strongly urged by Dr. Fines of Perpignan, by M. Piche, Dr. Collignon and others, and finally superintendents were appointed for the departments concerned, M. Leon Teisserenc de Bort on behalf of the Soc. Mét. de France undertaking to afford all possible co-operation.

In connection with the paper by Dr. Buys Ballot on Biarritz as a station for weather telegraphy, the importance of regular telegraphic reports from the Azores was urged by several speakers, and eventually a resolution embodying that view was carried unanimously, and the Portuguese representative (Dr. da Silva Amado) was requested to press it upon the attention of his government.

The practice of the Royal Meteorological Society of having all its stations photographed and the instruments inspected and verified every two years attracted considerable attention and was warmly approved, especially by the President of the Section, M. d'Abbadie.

At one of the evening meetings an interesting lecture on Storm Warnings and the Basis of their Issue was given by M. L. Teisserenc de Bort, being illustrated by a series of weather maps shown by one of Dubosq's electric lamps.

While at Biarritz I visited two out of the four meteorological stations in that town, unfortunately not having time to see the others. That at the Semaphore is practically the equivalent of an English climatological station with dry, wet, max. and min. thermometers and rain gauge. The thermometer stand was somewhat between a Glaisher and a Montsouris pattern, the position very exposed; in fact that of the rain-gauge is such that it cannot at all times fairly represent the amount falling in the town. The other station is at the Lighthouse, and the observations are under the Ministére de la Marine.

In connection with the Congress, there was an Exhibition of considerable merit. Meteorological instruments were exhibited by MM. Richard Fréres of Paris, by Tonnelot of Paris, and by one or two local firms. Meteorological literature was very well represented, and the publications on baths and mineral waters were to be numbered by hundreds. The walls of several rooms were covered with photographs, diagrams, architectural plans of bathing establishments, geological sections explanatory of the collection of the mineral waters, &c. This Exhibition was held in the lower rooms of the Biarritz Casino, which has unfortunately been subsequently burned, and I greatly fear that many of the above exhibits have perished. Some of the books exhibited were stated to be very rare; if so, the loss is the more to be regretted. It may be mentioned that a Diplome d'Honneur was awarded to the Royal Meteorological Society for its exhibit.

The excursions were of course of primary importance to the medical men, and it is obvious that my own impressions, based often merely on the weather of one day, can be of only little value. But, subject to full recognition of this fact, it seems to me that a few notes, based partly on my own experience, partly on the documents presented to the excursionists, and partly on other works already in my possession, may be generally useful.

The Pyrenees extend nearly 270 miles from West-south-west to East-north-east, viz. from the vicinity of Biarritz to that of Perpignan. The rainfall is not very accurately known, as until recently there have been few observations except at the large towns, which being generally distant from the mountains have naturally less rain. There is also reason to believe that the large quantity of water which falls as snow during the winter months has not always been accurately measured, and the rain-gauges have frequently been at a considerable height above the ground. All these causes lead me to believe that the fall of rain is greater than that indicated by the observations collected by M. Angot, which give only two small areas exceeding 56 ins., viz. one in the extreme west and another a little south-west of Bagnères de Bigorre (based possibly on observations made at Luz); all the rest of the chain may roughly be said to be reported to have for its maximum 52 ins. with a fall decreasing rapidly towards the north and east, so that in the plains of Gascony and Languedoc the fall is only about 28 ins. In the extreme east the coast line (forming the west coast of the Mediterranean) is extremely dry, some stations having less than 20 ins. In consequence of this, and of the high summer temperature, the preparation of salt by the natural evaporation of sea-water forms an important industry along the coast from Argelès-sur-Mer, past Perpignan, and as far north as Cette.

As regards temperature it is not easy to speak with certainty, and the best plan seems to be to take a few stations at which the observations are believed to be beyond suspicion, and give the values in a table :—

ABSTRACT OF SHADE TEMPERATURES IN THE PYRENEAN DISTRICT.

	Station	St. Martin de Hinx, Bayonne.	Pau.	Perpignan.	London.
	Observer	M. Carlier.	M. Otley.	Dr. Fines.	Mr. Symons.
	Duration of Observations	20 years.	15 years.	43 years.	28 years.
	Altitude	131 ft.	689 ft.	102 ft.	111 ft.
		°	°	°	°
YEAR.	Absolute Maximum	103·5	99·5	107·6	94·6
	Mean „	..	62·8	67·5	58·3
	Mean	55·8	55·4	59·4	49·4
	Mean Minimum	..	48·0	51·3	42·7
	Absolute „	8·8	9·0	18·5	6·7
JANUARY.	Absolute Maximum	74·7	72·0	76·5	56·4
	Mean „	..	48·4	53·2	43·3
	Mean..................	43·9	42·3	45·7	38·4
	Mean Minimum	..	36·1	38·8	33·8
	Absolute „	8·8	9·0	18·5	6·7

Biarritz.—Those who know Aberystwith can at once realise what are the general features of Biarritz. Perhaps the sands of Biarritz are rather finer, and the waves somewhat larger, but in almost all other respects the natural features are identical, but the difference of 9° of latitude gives in winter to Biarritz temperatures belonging to warmer months at Aberystwith. Without pretending to accuracy, it may be suggested that the corresponding months are roughly—

Aberystwith,	September	October	February	March	April	April.
	Oct.	Nov.	Dec.	Jan.	Feb.	March.
Biarritz,	57°·1	49°·0	42°·9	48°·9	46°·9	48°·9

It may be mentioned that several of the hotels at Biarritz are on a slope facing North-west, and probably 100 feet above sea-level. The drive of about three miles from Bayonne is very agreeable, being lined almost throughout with lofty plane trees. The great want in Biarritz seems to be gardens and squares inside the town, the almost fabulous prices asked for good sites for building seems to have prevented the authorities from preserving open spaces for future requirements. The numerous villas have their own private grounds; but if the town is to continue a gem, some of the land now offered for sale must be reserved for public use.

Cambo.—The first excursion was to this little station, which is about 12 miles south-east of Bayonne at the foot of the northern slope of the Pyrenees, with a large level plain to the north and hills of considerable height immediately to the south of it, near enough, that is to say, to make pleasant pedestrian excursions. The baths are near the river and not 200 ft. above sea-level; the principal hotel is much (perhaps 100 ft.) higher, and commands a landscape which, at the time of my visit, strongly reminded me of the lowlands of Scotland. (By the bye, there is a Cambo in the county of Fife. Is there any connection?) There are two classes of water, one containing sulphur at 72° F. and one containing iron at 59°.

I am not aware of any meteorological observations having been made either at Upper or Lower Cambo, but the air is said to be very pure, and so mild that the season extends from April 15th to November 15th.

Bayonne.—Bayonne is sometimes quoted as a health resort, but I consider that its claims to that title must be but small; some parts are certainly very unhealthy, and although there are very shady woods around the ramparts, it seems to me that Bayonne should be regarded rather as a small copy of Bordeaux, *i.e.* as a commercial centre, than as a health resort.

Dax.—This is a very important station, celebrated even in the time of the Romans as d'Aquæ Tarbellicæ and d'Aquæ Augustæ, as will be seen on referring to Pliny L. XXXI. Cap. ii., which Holland thus translates:—"There is in maner no region nor coast of the earth, but you shall see in one quarter or other waters gently rising and springing out of the ground here and there, yeelding fountains in one place cold, in another hot; yea and otherwhils there may be discovered one with another neere adjoyning: as for example, about Tarbelli,[1] a town in Guienne and the Pyrenæan hills, there do boile up hot and cold springs, so close one unto the other, that hardly any distance can be perceived between them." Dax is a low lying town on the bank of the Adour and only 40 ft. above sea-level, though it is 20 miles inland and 40 miles along the course of the Adour. The special characteristics of the place are, firstly, the enormous volume of its hot waters; secondly, its mud baths; and thirdly, its sedative climate. As regards the hot springs one yields 1,200 cubic metres (26,426 gallons) per diem, at the temperature of 147°·2; the basin in the middle of the town into which this spring discharges is about 50 ft. square, and even on the warm day of our visit was steaming away as if two or three locomotives were standing inside. The station is one at which mud baths are largely used, but of course I express no opinion upon these. The climate is considered most sedative—it is claimed to be exempt from great heat, and great cold, that snow is a rarity, that there is little rain and hardly any wind. Observations made in different parts of the town during 13 years, between 1865 and 1882, give mean temperature 57°·7; mean rainfall 43·82 ins.; mean number of fogs 22. The climate is very damp, the mean humidity being given as 84. A century since observations were made at Dax by Dr. Borda, and his records for 1781-1784 give the following values:—

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[1] Some think Baion in France.

	Winter.	Spring.	Summer.	Autumn.	Year.
Mean Temperature (4 years)	45°·0	55°·8	69°·6	56°·1	57°·4.

The following table is a conversion of one given by Dr. Lavielle in his *Guide* to Dax:—

	Mean Temperature.				
	Winter.	Spring.	Summer.	Autumn.	Year.
	°	°	°	°	°
Amélie les Bains ...	46·3	58·8	73·8	60·7	59·9
Cannes	48·2	60·4	75·6	64·4	62·1
Dax	47·0	60·1	69·7	54·3	57·7
Hyères	43·0	53·8	74·1	59·0	57·5
Mentone	48·6	61·2	76·3	63·1	62·2
Nice...	47·0	56·7	73·2	61·1	59·5
Pau	42·4	52·7	65·5	55·6	54·1

Dr. Dujardin-Beaumetz gives rather different figures (quoted from Dr. De Valcourt), of course I express no opinion on their relative merits:—

	Winter.	Spring.	Summer.	Autumn.	Year
	°	°	°	°	°
Arcachon	44·1	63·5	67·6	58·3	58·3
Dax...	46·8	59·5	73·6	63·1	60·6
Pau...	44·4	58·6	72·5	57·0	58·1

A fact which may throw some light upon the high winter temperature of Dax is mentioned by Dr. Barthe de Sandfort in his *Dax thermal.* With reference to the warming of the soil by the subterranean hot water, he says, "This indisputable fact has recently been verified during works connected with the Fontaine Chaude, when it was found, in Place Poyanne for example, that the soil at 6 ft. below the surface was generally at from 62° to 72° and in some places 77° F."

Arcachon.—This is a charming town, presenting several paradoxes, *e.g.* it is a sea bathing place yet is not on the coast; it is a double town, part being the summer station, part the winter; though a sea-bathing place it claims special salubrity owing to the abundance of its pine trees. It seems to consist of a pine-covered sand dune, reaching down to an inland lagoon protected from the swell of the Atlantic by a sandy strip of land. Dotted down all through this forest are numerous villas, many of them charmingly designed and fitted. The town is entirely new, therefore there are no "slums," and sanitary matters seem well attended to. The Moorish Casino is extremely good, I know of no English building in that style equal to it.

The rainfall at Arcachon is small, and coupled with the high summer temperature doubtless helps to explain one fact which seems to puzzle some of the residents, viz. the high specific gravity of the sea water, which is said to be quite 12 per cent. above that of the Atlantic. I infer that this is in part, if not wholly, due to evaporation.

A table of temperatures was given in the manual presented to the members of the Congress; I have converted the values into Fahrenheit degrees and reproduce the table.

THERMOMETRICAL OBSERVATIONS MADE IN THE SHADE IN THE FOREST UNDER THE SUPERVISION OF THE SCIENTIFIC SOCIETY OF ARCACHON.

Years.	8 a.m.					Noon.				
	Winter.	Spring.	Summer.	Autumn.	Year.	Winter.	Spring.	Summer.	Autumn.	Year.
	°	°	°	°	°	°	°	°	°	°
1865	41·4	55·6	69·1	57·6	55·8	46·2	63·7	75·7	66·4	63·0
1866	43·5	53·1	67·1	60·3	56·3	52·3	60·3	72·9	68·4	63·5
1867	46·6	56·7	68·9	54·5	56·7	53·4	63·7	76·8	62·2	62·4
1868	42·8	54·9	69·6	57·2	56·5	46·9	60·6	75·9	64·0	63·0
1869	46·2	53·6	72·0	54·0	56·8	53·2	58·8	75·7	62·2	62·2
1870	40·1	54·1	72·3	57·4	55·9	46·9	63·7	76·8	63·0	63·0
Mean ..	43·3	54·7	69·8	56·7	56·3	50·0	61·3	75·4	64·6	62·8

Pau.—Thanks chiefly to the influence of Sir Arthur Taylor, Pau occupied formerly an almost unapproached position in English estimation as a winter residence, and from information received it appears still to attract an influential body of visitors. I confess that I do not quite know why. According to the observations published by M. Piche,—and he as a skilled meteorologist, long resident in Pau, must be the highest authority,—the mean temperature of January is 42°·8, while at Penzance, according to the Meteorological Council, it is 44°·1, therefore our countrymen expatriate themselves in order to go to a place which has a reputation, but which is nearly 2° colder than our own best winter station in January; 0°·7 colder in February, and only warmer in March by 1°·6. I had no idea that the facts were as above stated, but when at Pau remarked that the vegetation looked like that of the warmer parts of Cornwall. My impression is that the English made a great mistake when they abandoned Tours and began to patronise Pau. Among other things, Pau has nearly twice the rainfall of Tours, and is twice as distant from Dover, The great feature of Pau is a terrace walk overlooking the Gave, and with a splendid unbroken view of the chain of the Pyrenees.

[Since writing the above I have stumbled upon the following note sent on January 15th, 1881, by one of my observers then staying at Pau:—"Snowing hard here for two days." And later still I have received a note from another of my correspondents, dated "Boulevard du Midi, Pau, December 4th, 1886," in which she says, "We are having very cold frosty weather. The thermometer last night registered 24° Fahrenheit, or 8° of frost."]

Eaux-Bonnes.—This is a lovely mountain station about 2,500 ft. above the sea and 30 miles from Pau. It is a summer station with endless rides and walks, the latter chiefly through woods in which also great lengths of almost horizontal terraced walks have been cut. I have not heard of any meteorological observations having been made there, but my impression is that its climate must be somewhat like that of the higher part of the English Lake District, or Loch Katrine, but rather warmer. The principal hotel (Grand Hôtel des Princes) was closed for the season, but opened for the *déjeuner* to the Congress, and would form a very charming residence for a fortnight or so.

Eaux-Chaudes.—This is only eight miles from Eaux-Bonnes, with a regular omnibus service, and the road to it is grand almost beyond description, having been blasted out of the side of a nearly perpendicular cliff: the view along the gorge for a mile or two before reaching the baths is ample reward for many an hour's weary travel. The little village is about 2,200 ft. above the sea, and below it in the gorge are the bathing establishments. The temperature of the different springs ranges from 97° downwards. The bathing season is from June 1st to September 30th, and during that season the air is very mild, and the climate much sought after because "of the uniformity of the day temperature between 63° and 68°, maintained by a local breeze which from sunrise to sunset blows gently along the gorge."

Cauterets.—This was the next station visited by the Members of the Congress, but as I remained at Pau over the Sunday, my remarks can only be based on the publications presented to me by Dr. Duhourcau, of Cauterets, and on the photographs which I obtained. The resident population is about 1,800, and there is in addition accommodation for 6,000 visitors. The season consists of six months from May 1st, and, though more than 3,000 ft. above sea level, during this half of the year it is rarely cold; the absolute minimum is said to be 39° and the maximum 86°, the mean temperature at 6 a.m. 54°·5 and at 2 p.m. 66°·2. The town is now well provided with pure drinking water and good drains, and is remarkably healthy; among the 22,000 visitors each season, many of them seriously ill, the deaths rarely reach 15. The quantity of thermal water is immense, 330,000 gallons per diem, at temperatures ranging from 133° to 93°. I did not hear a single adverse remark upon Cauterets from any one of the 150 Congressists who visited it.

Lourdes.—This was not visited by the Congress, as it is not regarded as a health resort, and there are no mineral waters of medical repute. However this may be, whether or not the water from the celebrated grotto contains notable chemical ingredients—they are not readily perceptible to the taste or smell—this much is certain, that the crutches and other supports left behind by those who have visited there must already exceed a hundred. I merely record the fact, and add that whatever the ordinary climate may be, October 11th, 1886, was bright, crisp and very sunny.

Bagneres de Bigorre.—A very interesting town of about 10,000 inhabitants, 1,820 ft. above sea, and almost surrounded by lofty mountains. The town is irregularly built, and possesses few notable edifices except the Casino and the bathing establishment—the former is of extremely good design: the bathing premises are very plain, but were stated to be very well organised. The baths are open all through the year, but are most frequented during the summer. The climate is considered warm and relaxing rather than otherwise, and so I found it as it happened. The hills round the town are well wooded, and shady paths are numerous.

Luchon. or, as it is sometimes called, Bagnères de Luchon, is a charming town, not very large (the resident population being fewer than 4,000), but with ample accommodation for visitors, and many things to tempt them to stay. The streets are lined with plane trees, of which the trunks are in many cases 9 ft. in circumference, and lofty in proportion. The Casino and the garden in which it stands, with its lakes, flowers, electric lighting, &c., would be an acquisition to London, while all is set in a framework of mountains; the town itself is 2,000 ft. above the sea, but all around are peaks ranging from 4,000 to 11,000 ft. The thermal establishment is very large, and is, I believe, very well organised in all respects. Luchon may also be considered as one of the very best centres from which to visit the various picturesque valleys of the Pyrenees. I have not seen any thermometrical records from Luchon, but according to M. Angot's rainfall map it is one of the driest places in the Pyrenees, having less than 40 ins. per annum. M. Angot is always so careful that he doubtless has returns which justify this value, but as no record from Luchon is to be found in the last volume of *Pluies en France*, 1882, one may perhaps be permitted to wish for some modern returns.

Ussat.—A very small place, near Tarascon (Ariège), about 50 miles in a straight line from Luchon, but nearly 150 miles by train. There are few houses except the large hotels, the bathing establishment, and the post-office. It is a summer station (June 1st to October 1st), 1,400 ft. above sea-level, at the southern base of the magnificent cliffs which form the north-east bank of the Ariège, and from which the thermal water (104°) flows. These nearly perpendicular cliffs are said to be 1,800 ft. high, but they look even more. The valley is perhaps a mile across; and on the south side the hills, though less abrupt and less lofty, are specially interesting on account of the numerous and extensive caves which they contain.

No thermometric observations have been published, but the station is probably rather hot, though I did not notice any specially tropical vegetation. On the right bank of the river (the north side) there is a large grassy park or common, and the hotels have good gardens.

Ax,—or Ax-les-Bains or Ax-sur-l'Ariege.—is a somewhat large town south-east of Ussat, and 16 miles from Tarascon, which at present is the nearest railway station. The line will, however, probably reach Ax in 1887 or 1888, as most of the heavy works are complete. Ax is quite in the heart of the Pyrenees at the intersection of several valleys, is between 2,000 and 3,000 ft. above sea-level, and surrounded by lovely scenery. The quantity, heat, and strength of the sulphur springs are remarkable, water at the temperature of

160° is continuously running in steaming streams by the road side, it is so strongly charged with sulphuretted hydrogen that bright silver plunged in it for two minutes took a colour which lasted for a week in spite of rubbing. One of the smaller establishments takes a daily supply of 88,000 gallons; there is, however, far more water than all the establishments together could ever utilise. Here is the public hot bath established by Louis IX. for the use of lepers, but now chiefly devoted to washing purposes.

Montpellier.—From Ax we were obliged to return to Toulouse in order to pass to the eastern end of the Pyrenees. This took us past the excessively interesting cité of Carcassone to Narbonne Junction, and as that is only some 50 miles from Montpellier the Congress went there. It is a large and in some respects handsome city, population 55,000. Formerly a fashionable health resort, it has now I believe, on account of the strength of the winds, nearly lost its reputation. In protected places there are, however, trees which prove the absence of hard frosts, *e.g.* in the garden of the hotel there was a magnolia quite 40 feet high, while abundance of hardy trees decorate the parks and squares. This was the first place at which we saw any mosquitos.

A large party of the Congressists were kindly taken by the Municipality to the Agricultural School, and Dr. Crova gave an interesting lecture on the meteorological work of the Commission of the Department of Hérault and of the Observatory of Montpellier, which he has long directed; and after the lecture he accompanied the members in their examination of all the instruments. As I hope on a future occasion to submit a few notes by Mr. Inwards and myself upon the meteorological observatories of the South of France—Montpellier, Perpignan, Nice and others—I omit details for the present.

Cette.—On the journey from Montpellier to Perpignan, the Congressists stopped at this port. There is a good panoramic view from the Signal station, but I could not advise any one to select Cette as a residence. As regards frosts, a paper by M. Doumet-Adanson shows that on the average of twenty years there are 37 days with frost; the average minimum is 18°·1, and in the winter of 1863-64 it fell to 10°·4. No wonder that tropical vegetation was not to be found.

Boulou, or Le Boulou, is an iron spring on the river Tech, 15 miles south of Perpignan and 10 miles north-east of Amélie-les-Bains; it is not very high, and lies at the foot of a spur of the Pyrenees. There are no meteorological records, but the abundance of aloes in the sides of the road, and some fairly good orange trees in the garden, tell a tale of sunshine and of few frosts. The feature which astonished me most was the very large quantity of carbonic acid gas continually bubbling up through the water, in fact one small reservoir was always full of the gas, which escaped and flowed down along the path. A Grotta del Cane could easily be formed here of any required size. The waters are said to be almost identical with those of Vichy.

Amelie-les-Bains.—A romantic village on the Tech, at present 25 miles from the nearest railway station, but soon to have one. Only 900 ft. above sea level, and surrounded by lofty ranges. Extensive Roman baths were found here, and many relics are still to be seen, but unhappily the baths have been so modernised that little but the name remains. The hotels and bathing establishment are on a very large scale and in high repute. The temperature of the sulphur water varies from 145° downwards. There is a large Military Hospital here with its own special baths.

The climate, owing it is said to "the warm Vent d'Espagne," is so mild that patients can stop throughout the winter, a quality which, according to one authority, renders it unique in Europe.

La Preste.—This is about 22 miles from Amélie-les-Bains, and therefore 47 miles from the nearest railway station and within 2 or 3 miles of the Spanish frontier, and is 3,707 ft. above the sea. North winds cannot reach it and hence it is said never to be cold, and the baths are open all the year. Mademoiselle Mathilde Faure, the daughter of the proprietor of the establishment, has been furnished by Dr. Fines with standard thermometers and two rain-gauges; I found them all in good order and the lady herself an accurate observer, so that all uncertainty as to the climate of this interesting station will soon cease. This station was formerly, indeed until quite recently, only accessible on mules, but now there is a splendid road—and the French make superb roads—all the way to Perpignan.

I left the party at Amélie-les-Bains, as I was anxious to get to the Riviera but my friend Mr. Inwards continued with the Congress a few days longer, and has kindly given me the two following notes.

At **Banyuls-sur-Mer,** a little fishing town near the Spanish frontier, the French Government have established an excellent Zoological Laboratory, which is now in full action, and it is probable that sea temperature observations may be forthcoming from this part of the coast of the Mediterranean.

At **Thues** there are numerous hot-springs, the temperature of one of them reaching 79° Centigrade (174°·2 F.). In some of these springs, notwithstanding the temperature and the chemical impurities, there were small water snails living and thriving in the hot water close to the place where it gushes out of the rock.

DISCUSSION.

Mr. INWARDS said he could corroborate all that Mr. Symons had written concerning the various places visited. He specially called attention to the interesting fact of the constancy of the temperature of the waters of the mineral spring at Thues. The temperature, carefully determined by a Fellow of the Royal Society as long ago as 1838, was found to be 77°·5 Cent., (171°·5 F.), and on our visit to the place in October last we were informed that it now reached 79° C. (174°·2 F.), so that it is perhaps noteworthy that there had been so little change in so long a time.

Dr. WILLIAMS said the information given in Mr. Symons's paper was very interesting to him, as he was well acquainted with the various places mentioned, having visited most of them about twenty-five years ago, and having studied the climate of the whole district pretty thoroughly. He was rather disappointed that no general remarks as to the meteorological features of the Pyrenees district, based on the configuration of the mountains and valleys, had been made, as he was expecting that Mr. Symons would have done so. The most remarkable feature perhaps in the climate of this district was the character of the winds. When the winds blew from anywhere southward the rush through the "gates" or "ports" in the mountain chain was most tremendous, and in fact was so severe as to have given rise to the proverb,—"The father never waits for the son, and the mother never waits for the daughter." In no part of the world were there so many hot springs as in the Pyrenees district of Southern France. He believed there were over 200 of them. The features of these springs were their sulphurous character, and their always appearing at the junction of the granite with the limestone. The French doctors greatly believed in the curative effects of sulphur, and claimed that the taking of the waters of these springs cured bronchitis and chest diseases and even consumption. He had not met with any cases of consumption being cured by the use of these waters, but he certainly knew they were of some good in cases of rheumatism. Regarding the climate of Pau, he might perhaps be allowed to refer to a book[1] written by himself, in which part of a chapter had been devoted to a discussion of the character of the weather at Pau during ten years. He had there shown that the climate of this place was both cold and moist, the rainfall being considerable, but the most remarkable feature was the great calmness of the air. It is now used by invalids as a spring residence rather than a winter resort. Pau would be a very damp place but for the remarkably porous character of the soil, which allowed all precipitation speedily to percolate through it. Some years ago he compared the curative results experienced by patients wintering at Pau with patients who had wintered in Egypt or some other of the Mediterranean winter resorts, and Pau came out the worst of all. This result of course brought down upon him the indignation and anger of those interested in the character of Pau as a winter health resort, and the discussion of the question was carried on in the French local newspapers very warmly for six months. A paper was subsequently read before the Sanitary Institute of Great Britain, by Dr. Pietra Santa, in which he strove to vindicate the climate of Pau as a health resort, and he (Dr. Williams) had the privilege during the discussion of making an effective reply to the statements advanced in the paper. The whole district of the Pyrenees was a very interesting region, and he hoped that Mr. Symons would be able to favour them at some future time with some further account, more especially of the Pic du Midi Observatory and its surroundings.

Dr. TRIPE said he did not feel able to offer any remarks of interest regarding the information given by Mr. Symons. Had he known the manner in which the Paper was to be written, and the kind of information that it was intended to give, he could have stated some of his friends' experience of the value of the places visited for health resorts and winter residence. He could only say regarding the climate of Pau, that it certainly was not a desirable place for an invalid to winter in. In fact a friend of his, who had stayed there during part of one winter, described the climate as "execrable," being very changeable, cold, windy and with occasional snowstorms. He left before the winter was over. The mean monthly winter temperature was only a little more than 2° above that of Greenwich.

Mr. LAUGHTON inquired whether Mr. Symons had, during these excursions, been able to gain any information respecting the day and night winds of the Pyrenees, which have been described as blowing in a manner somewhat resembling land and sea breezes, more especially near the western end of the range. He should be very glad if Mr. Symons could refer him to any sources of accurate knowledge.

Mr. SYMONS in reply said he heard nothing whatever of the winds referred to by Mr. Laughton. The excursions were so hurried, and so large an area of country was travelled over in so short a time, that it was only possible to make note of a few of the principal impressions received. He had consulted little literature relating to the general climatic features of the district, and had therefore not referred to Dr. Williams's book. So enormous a number of books existed bearing on the climate and hydrology of health resorts, that he was altogether unable to study or read the older ones; his own collection of bound volumes of this class occupied 18 ft. of shelving, and of course there were scores of pamphlets besides; but he had read carefully all those prepared for and presented to the Congressists. He had purposely expressed few opinions as to the character and value as health resorts of the places visited, for the reasons stated in the beginning of his Paper.

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[1] *Climate of the South of France*, 2nd Edition.

REPORT ON THE
PHENOLOGICAL OBSERVATIONS FOR 1886.

By the Rev. T. A. PRESTON, M.A., F.R.Met.Soc.

[Read December 15th, 1886.]

The set of returns sent in for last year is very satisfactory, though some are unfortunately very fragmentary and some have been spoilt at times by "absence from home." It would be desirable if more specimens were sent in, as, in such exceptional years as the past, every possible confirmation of entries is necessary; there is also at times the same want of definiteness in recording the dates as has been alluded to in former years. Such notes as "in bloom," "fairly in flower," give, it is true, some materials for comparison between last year's dates and those from the same places in former years, but quite prevent the comparison of those places with others on the list.

There are slightly fewer Returns than formerly, but the old observers have almost all continued to send in their reports, and these become more and more valuable every year. The "general summaries" sent in by some observers, especially that from Harpenden, have been of great service in drawing up the present Report.

The following is the list of stations and observers:—

Station.	*County.*	*Observer.*
*Addington	Buckingham	J. Mathison.
Arboe	Co. Tyrone	Rev. C. L. Garnett.
*Babbacombe	Devon	E. E. Glyde.
Belton	Lincoln	Miss F. H. Woolward.
*Bocking	Essex	H. S. Tabor.
Buckhorn Weston	Dorset	Miss H. K. H. D'Aeth.
Cardington	Bedford	J. McLaren.
*Croydon	Surrey	W. F. Miller.
Cushendun	Co. Antrim	Rev. S. A. Brenan.
Detling, Maidstone	Kent	R. Cooke.
Durham	Durham	H. J. Carpenter.
Ealing	Middlesex	A. Belt.
Geldeston	Norfolk	Miss S. S. Dowson.
*Guernsey	Channel Islands	Miss M. Dauber.
*Hampson, Lancaster	Lancaster	The Misses Johnson.
Harpenden	Hertford	J. J. Willis.
Hertford	Hertford	R. T. Andrews.
*Hodsock	Nottingham	Miss A. Mellish.
Killarney	Co. Kerry	Ven. Archdeacon Wynne, M.A.

* Send specimens.

Station.	*County.*	*Observer.*
Lewisham	Kent	H. T. Stainton, F.R.S.
*Maresfield	Sussex	Mrs. Green.
Marlborough	Wilts.	Rev. T. N. Hart-Smith, M.A.
*Northampton	Northampton	H. N. Dixon.
Norwich	Norfolk	A. W. Preston.
*Oxford	Oxford	F. A. Bellamy.
Pennington	Hants	Miss E. S. Lomer.
St. Michael's-on-Wyre	Lancaster	Miss S. Hornby.
*Salisbury	Wilts	W. Hussey.
Strathfield Turgiss	Hants	Rev. C. H. Griffith.
*Tacolneston	Norfolk	Miss E. J. Barrow.
*Thurcaston	Leicester	Rev. T. A. Preston, M.A.
Tidenham	Gloucester	Miss K. Evans.
*Tiverton	Devon	Miss M. E. Gill.
Tunbridge Wells	Kent	G. S. Saunders.
Usk	Monmouth	C. Mostyn.
*Ware	Hertford	Lieut. R. B. Croft.
Wellington College	Berks	S. A. Saunders.
*Wells	Somerset	The Misses Livett.
*Westward Ho	Devon	H. A. Evans.
*Wickham	Essex	H. N. Dixon.
Wicklow	Co. Wicklow	The Misses Wynne.

BOTANY.

In the account of the severe winter of 1885-1886, Mr. C. Harding states that " October was cold and cheerless, and the sensation was that we had suddenly been plunged into mid-winter; the cold continued throughout the month and was uniform over the whole country. November was particularly gloomy and damp, and the ground and air were kept in a state of saturation. December was a constant alternation, the weather at one time being open and mild, whilst at another it was cold and frosty. January was cold over the whole of the United Kingdom, but the weather was extremely unsettled, severe frosts alternating with brief periods of thaw. Heavy falls of snow were experienced generally over the whole country. February was cold and dreary from beginning to end. March was cold, but very opposite conditions of weather were experienced during the month. From the commencement to the 18th intense cold prevailed, accompanied with biting East winds. After the 18th the frost entirely broke up, and for the remainder of the month the weather was unusually mild for the season."[1]

The reports sent in by the different observers, allowing for local variations, as a rule fully bear out the above summary, and it was therefore to be expected that vegetation would be singularly delayed. The most remarkable exception to the general rule was at Tiverton, in Devonshire. The observer there states: "We had a singularly mild autumn—that is, till December 8th we had no cold weather at all, then a frosty night was followed by four days of sharp frost, which cut off all the flowers; before this they had been unusually abundant (as many as 126 species were gathered in October, 106 in November, and 47 in December); it was easy to get a bright wild-flower bouquet in both October and November, and quite as many could have been procured during the first week in December." This is, however, quite exceptional, and the locality must be considered a very favoured one. Even in Guernsey they had very severe weather. Ripe Raspberries from out of doors were to be purchased in the market on October 10th, but the high winds there, as elsewhere, hastened defoliation, and by the end of the month trees were generally leafless all over England; "they were quite as much defoliated (in Guernsey) as they were last year in the second week in December." The full autumn tints lasted but a very short time, as the heavy rains and high winds during the last few days of the month stripped the trees. Swallows were seen as late as November 24th in Guernsey and October 31st at Geldeston; with these exceptions, the reports for the three months have been most scanty—vegetation was quite dormant.

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* Send specimens.

[1] *Quarterly Journal*, Vol. XII. p. 224.

It may be presumed that, till the middle of March, things were very backward, and the general tone of the reports is to that effect. Everything was very late in coming into flower, but, from the cold being prolonged rather than intense, there has seldom been a season when plants have lasted so long in flower. Winter Aconites, in Leicestershire, though they began to flower on December 23rd, lasted till nearly the end of March, fully three months, and Snowdrops were gathered as late as April 30th. At Lewisham they lasted till the end of March. This may be considered as one of the most striking features of the season.

The occasional gleams of fine weather in January induced a Thrush or Lark to sing just for the time, and the Rooks assembled about their old nests early in the month, but were dispersed by the return of cold weather; Bees also were tempted out for a short time, but with these exceptions animal and vegetable life were almost dormant, and "gardens were singularly flowerless." Violets, Snowdrops and Hepaticas were in flower on January 28th at Tiverton, but in many places they did not flower at all in January. In Guernsey Sweet Violets, Roses, and Geraniums were gathered every week through November, December and January.

During February "vegetation was exceedingly dormant; although the weather during the first week was fair, yet the remainder of the month was so gloomy and foggy, with severe frosts, and so little bright sunshine, that under many of the hedges in the neighbourhood of Harpenden, snow, which fell on January 6th, was to be seen unmelted at the end of February." At Tiverton, only 18 flowers could be found. The Dog's Mercury was in bud on the 20th, but was unopened by the end of the month. At that time, at Salisbury, the Crocus was just becoming frequent, and at Hodsock Winter Aconites and Snowdrops were in full flower, and the Hazel was by no means in perfection; near Leicester, this did not flower till the 25th. Near Oxford, the Dog's Mercury was cut down and did not revive. It would have been in flower by the end of the month, but a "second crop" had to be observed.

Up to March 18th, everything remained very dormant, but a sudden change came everywhere about that date, and "the transformation in the appearance of gardens was perfectly marvellous." At Lewisham "the first Crocus opened on February 22nd, and by the second week in March about thirty came into flower (in a warm spot), but only one or two were to be seen in the kitchen garden on March 18th; but on March 19th they were in hundreds." This sudden change is universally noted, and for the rest of the month vegetation progressed, the hedges assuming a green tint and pastures recovering very rapidly, to the delight of the farmers, as food for their stock was getting very scarce.

The extreme backwardness of vegetable growth at this time may be gathered from the Table, but it may be noted that at Harpenden the Celandine was twenty-six days later than in 1884, the Whitlow-grass twenty-five days, Coltsfoot twenty-two days, Dog's Mercury and Wych Elm thirty-one days. At Geldeston only twenty-two plants were in flower, as against forty-two in 1882 and forty-three in 1884.

"From the Agricultural Reports we learn that the cruel winds of February and March greatly injured the Wheat plant, particularly on the lighter descriptions of soil, but the medium and heavier classes of soil maintained their crops surprisingly." About Wells the Geranium cuttings universally damped off; the weather was dry, and it is therefore presumed that this damping off was caused by the wet autumn after they had struck. At Detling "the ground worked splendidly for getting in the Lent corn; Hop-garden work was delayed quite a fortnight; early spring flowers suffered severely, and the Yew was also injured badly."

At Buckhorn Weston "the severe frost killed many birds and drove others—including Plovers—right up to the houses in search of food." At Hampson "the season was unusually late for birds. Before the last great storm of March 1st, Fieldfares came in large flocks near the house. The Goldcrest, which almost always comes about the house before great storms, has hardly been seen this month, except on the last day of February." Swallows and their allies appeared towards the end of the month, but merely for a short time, not appearing again for some weeks in some localities. Butterflies occasionally came out of their winter quarters during the fine weather, but were scarce; and Wasps also appeared, becoming unusually numerous later on, though they, in common with Butterflies, were "conspicuous by their absence" during the autumn. This is a second point in which the year has been remarkable.

Notwithstanding the favourable weather during the latter half of March, vegetation was generally backward in April. At Harpenden "the backwardness of the season is phenomenal; on May 1st vegetation was about as advanced as it ordinarily is in the first week of April. It is true the Swallow was seen at Harpenden on the 18th and the Nightingale heard on April

TABLE I.—Date (Day of Year) of First Flowering.

Name of Plant.	Babbacombe.	Buckhorn Weston.	Westward Ho.	Wells.	Tiverton.	Croydon.	Ealing.	Strathfield T.	Pennington.	Marlborough.	Salisbury.	Oxford.	Addington.	Northampton.	Uak.	Thurcaston.	Harpenden.	Hertford.	Bocking.	Belton.	Tacolneston.	Norwich.	Hodsock.	Hampson.	Cushendun.	Killarney.	Wicklow.	Guernsey.
A. Nemorosa	..	103	91	93	102	93	..	105	..	89	82	90	101	106	91	(97)	93	91	109	88	96	103	94	92	100	76	96	..
R. ficaria	57	60	51	56	79	80	91	87	..	14	79	67	82	88	57	82	85	39	92	38	81	91	79	81	65	41	53	20
R. acris	140	117	128	(132)	128	(141)	128	119	127	120	125	126	153	120	121	132	120	104	..	145	..	126	143	138	133	118	143	107
C. palustris	95	86	92	..	104	105	..	96	..	83	93	94	102	87	91	101	105	110	112	94	96	98	108	..	109	84	96	104
P. Rhœas	169	156	162	..	145	(164)	194	164	163	156	155	162	..	163	(155)	198	159	153	..	160	155	162	166	..	..	188	167	..
Nast officinale ..	..	115	146	..	(152)	(170)	..	157	148	120	160	179	..	165	..	..	..	..	..	..	..	154	173	..	..	159	(160)	130
Card. pratensis....	114	111	..	118	112	(116)	116	104	..	117	105	115	116	116	98	121	120	111	120	121	112	126	123	120	112	109	125	117
S. Alliaria	..	109	101	(117)	116	(111)	116	117	..	120	119	106	..	114	..	116	122	110	119	125	116	113	113	..	..	(115)	117	120
D. verna	79	102	68	(61)	72	80	..	83	..	84	59	36	82	2	..	(99)	90	94	..	80	..	80	..	(71)	..	..	..	54
V. odorata	..	83	52	85	89	(90)	..	95	..	84	85	89	87	87	75	..	83	92	..	82	..	80	83	..	..	..	..	..
Polygala vulgaris ..	..	122	130	..	159	129	..	148	..	128	119	..	156	128	173	..	151	158	..	..	..	175	..	(154)	138	124	132	40
L. Flos-cuculi	164	154	152	..	(157)	(148)	..	155	125	156	146	151	..	158	156	..	152	155	..	162	151	157	163	..	..	159	160	120
S. Holostea	102	111	89	113	104	(111)	116	108	..	115	105	112	..	116	102	124	115	104	113	131	104	119	124	115	122	94	117	..
Malva sylvestris	168	172	157	168	182	170	180	188	161	171	166	195	..	178	181	182	..	168	..	..	173	175	181	..	..	(189)	(180)	151
H. tetrapterum	203	201	198	..	(200)	..	..	199	195	189	195	..	..	..	..	..	..	..	..	..	..	..	207	197	..	(179)	214	201
H. pulchrum	182	..	184	..	182	(185)	..	194	..	184	187	..	..	..	186	..	184	..	..	..	..	..	.	182	..	..	..	177
G. Robertianum ..	105	125	118	121	116	128	..	136	137	129	(125)	118	141	137	124	141	129	108	135	138	117	145	141	138	..	..	126	123
E. europæus	..	149	150	..	161	157	..	150	156	157	..	..	156	165	164	..	160	159	..	157	..	..	167	..	..	148	170	..
A. Pseudo-platanus	..	120	121	..	120	122	123	151	126	125	120	125	130	120	122	129	127	124	134	123	..	124	123	(139)	152	104	125	119
Æ. Hippocastanum	132	121	117	128	(117)	125	126	132	..	127	120	124	130	128	126	127	141	..	134	128	131	127	129	..	..	116	126	120
C. Laburnum......	139	143	131	132	(134)	134	137	147	..	135	..	134	141	134	129	139	145	134	(149)	140	142	137	143	143	153	123	140	..
T. repens	160	154	149	168	(144)	(136)	..	164	155	154	156	167	159	142	145	158	157	136	..	150	..	..	157	..	(155)	152	143	123
L. corniculatus	143	124	130	143	159	(136)	177	152	..	135	..	158	152	142	129	(166)	159	152	152	143	151	154	153	146	134	135	125	114
V. Cracca	175	166	172	174	..	168	..	181	172	175	167	179	180	181	184	196	183	165	174	182	171	..	185	181	..	175	178	169
V. sepium	124	114	113	127	118	(128)	..	138	131	126	125	145	..	142	129	..	128	137	(149)	..	128	..	142	(126)	..	..	129	125
Lath. pratensis....	168	153	150	163	156	165	174	172	151	155	151	167	159	163	162	185	160	156	174	172	157	157	183	..	175	116	153	160
P. spinosa	100	110	..	107	109	(116)	116	109	..	116	103	..	110	113	107	114	112	105	114	115	112	98	114	..	112	84	100	87
S. Ulmaria	177	169	172	176	182	(180)	192	177	182	176	172	174	173	178	177	198	184	163	176	183	..	..	185	181	..	179	186	..
P. anserina	138	140	128	152	(133)	(150)	181	137	133	135	146	131	152	139	136	153	147	148	152	161	152	175	161	156	142	142	146	140
R. canina	163	158	157	159	163	..	175	160	166	161	160	163	153	163	163	167	159	161	162	171	166	174	173	..	(193)	161	171	155
P. Aucuparia	..	135	154	..	(134)	129	126	124	..	139	..	..	149	142	135	(132)	150	..	(149)	136	..	138	144	..	..	126	155	128
C. Oxyacantha	139	132	128	133	(134)	129	139	142	137	142	..	132	..	138	140	143	144	139	(149)	139	143	141	142	149	147	127	147	127
E. hirsutum	(199)	184	185	..	201	196	186	200	182	195	197	198	..	192	187	201	..	166	188	202	..	197	208	..	..	..	205	198
E. montanum	..	..	157	168	159	165	173	195	169	168	173	..	..	165	166	169	172	161	174	..	..	..	170	..	185	159	174	..
Angelica sylvestris	..	221	..	..	..	..	..	206	211	..	195	..	..	..	..	..	..	..	217	116	..	..	215	..	..	..	..	..
D. Carota	..	176	180	..	..	(190)	..	153	172	183	175	..	..	166	..	..	..	..	..	..	..	..	..	..	..	..	172	139
H. Helix	273	..	264	256	292	262	..	267	256	290	254	..	..	262	..	291	..	..	250	..	..	..	..	..	..	250	..	255
C. sanguinea	..	162	..	163	..	(175)	165	171	178	171	167	161	153	180	160	..	183	..	174	155	..	..	157	..	..	139	..	..
Syringa vulgaris ..	138	126	121	127	(120)	129	130	138	..	132	..	127	130	128	129	138	140	131	134	136	..	136	138	144	145	127	133	126
G. Aparine	142	141	118	128	(148)	129	..	108	131	129	146	136	146	136	153	158	145	..	152	130	..	145	153	..	..	162	167	143

TABLE I.—Date (Day of Year) of First Flowering.—*Continued.*

Name of Plant.	Babbacombe.	Buckhorn Weston.	Westward Ho.	Wells.	Tiverton.	Croydon.	Ealing.	Strathfield T.	Pennington.	Marlborough.	Salisbury.	Oxford	Addington.	Northampton.	Usk.	Thurcaston.	Harpenden.	Hertford.	Bocking.	Belton.	Tacolneston.	Norwich.	Hodsock.	Hampson.	Cushendun.	Killarney.	Wicklow.	Guernsey.
G. verum	178	179	173	186	..	(185)	..	186	189	184	183	195	180	..	..	187	183	..	..	192	..	..	192	..	(193)	189	194	158
Dipsacus sylvestris	..	197	..	..	..	(202)	..	191	209	.	207	..	..	..	..	..	..	..	..	..	..	..	221	..	..	..	..	208
S. succisa	211	233	..	..	228	(215)	..	186	173	191	173	..	..	..	..	..	..	..	243	..	..	..	..	..	..	(178)	..	..
Petasites vulgaris ..	..	..	..	96	(110)	..	..	95	..	65	91	..	99	..	..	..	..	91	..	90	..	..	97	..	..	..	..	..
T. FARFARA	84	74	73	95	81	73	..	90	..	80	79	84	80	78	73	(76)	79	56	94	84	..	98	81	83	78	78	79	..
A. MILLEFOLIUM ..	180	177	164	186	166	170	178	165	172	155	175	168	173	163	176	195	172	166	187	180	..	..	..	189	..	172	180	160
C. Leucanthemum ..	139	133	152	152	(135)	145	147	144	155	(153)	151	151	149	142	145	159	146	152	154	163	..	151	164	..	155	144	149	124
Artemisia vulgaris	..	..	..	..	..	192	..	..	203	..	197	..	..	..	..	..	..	..	..	..	..	..	212	..	..	..	..	226
S. Jacobæa	192	..	187	..	194	192	..	153	163	182	186	..	..	192	186	..	170	179	..	..	..	..	196	..	(193)	194	191	164
C. NIGRA	196	181	180	(174)	176	170	186	171	172	175	168	172	..	173	176	180	182	165	175	..	..	..	189	190	..	189	186	169
C. lanceolatus ..	181	..	181	..	201	(202)	..	195	..	197	191	168	..	..	177	193	182	167	201	..	..	..	198	..	..	190	..	175
C. arvensis	187	186	183	..	201	185	187	190	186	189	182	..	..	..	187	193	188	158	188	..	..	..	194	..	..	184	..	..
Sonchus arvensis ..	..	202	(191)	..	..	(190)	..	152	190	..	208	..	..	..	..	215	..	..	232	..	..	..	214	..	..	177	(235)	199
H. Pilosella	140	146	141	150	159	143	..	151	148	149	..	..	..	149	146	175	156	136	153	151	158	152	157	..	158	145	150	141
C. ROTUNDIFOLIA ..	..	..	..	..	..	198	..	183	173	175	173	..	..	180	199	(198)	171	..	..	195	..	198	196	197	..	..	..	..
Ligustrum vulgare	169	167	177	163	166	(175)	183	182	161	177	167	167	..	180	178	187	173	..	..	187	..	..	182	..	..	165	(180)	164
CONV. SEPIUM	216	186	183	183	201	(192)	204	189	191	192	187	202	..	199	187	..	190	..	201	..	..	..	197	..	..	207	213	..
Symph. officinale ..	166	140	150	119	156	(164)	..	164	131	120	..	128	..	..	129	..	..	..	..	..	..	135	..	..	..	145	..	141
Pedic. sylvatica ..	..	123	129	..	(117)	129	..	140	129	129	119	..	..	128	..	..	..	155	..	125	..	175	..	135	138	126	125	107
V. Chamædrys	(104)	116	103	..	99	121	..	67	..	124	107	124	121	124	123	135	126	115	135	127	119	101	137	..	127	125	127	83
Mentha aquatica ..	223	..	..	..	222	..	..	224	209	..	218	..	..	..	.	..	..	..	217	..	..	..	227	..	..	(213)	(241)	221
T. Serpyllum	164	..	174	184	..	192	..	184	156	162	156	166	..	(170)	..	..	188	166	..	172	..	..	..	..	..	..	(202)	158
Prunella vulgaris ..	166	166	166	..	175	183	205	177	163	171	170	167	159	169	..	183	173	175	188	178	..	197	(176)	(187)	..	168	170	146
N. Glechoma	100	98	91	(103)	96	114	..	114	..	90	93	106	93	108	..	120	114	102	120	103	101	113	119	..	..	69	113	115
G. Tetrahit	..	201	..	..	195	200	..	169	..	178	188	198	..	..	..	..	..	..	..	..	..	..	(205)	..	..	..	..	..
Stachys sylvatica ..	..	168	159	170	175	165	164	180	161	172	166	179	..	165	168	175	161	167	(172)	172	..	..	179	(181)	..	..	(174)	164
A. reptans	130	120	(127)	(129)	(134)	128	..	136	129	127	124	151	126	136	126	151	143	131	134	131	129	..	141	136	..	127	136	126
P. VERIS	99	82	..	106	..	(114)	(113)	95	..	91	93	91	91	113	111	114	90	102	95	113	90	117	109	..	113	105	112	..
P. lanceolata	122	110	105	126	116	122	135	126	..	126	114	119	..	120	..	123	127	122	152	125	..	..	125	..	123	(100)	114	94
M. perennis	83	40	38	78	81	(66)	..	86	..	83	79	(85)	..	..	..	104	84	88	92	86	83	98	85	42	..	..	..	..
U. montana	..	123	..	..	..	(90)	120	120	..	87	81	(78)	93	..	..	90	85	88	94	85	..	85	84	..	..	40	107	..
S. Caprea	95	91	..	92	90	88	..	77	..	87	85	(85)	..	..	86	(91)	94	91	94	90	85	84	87	87	(91)	66	86	73
Fagus sylvatica ..	..	131	..	..	..	(141)	..	148	..	127	..	..	124	..	126	133	..	..	..	136	..	..	..	..	..	..	..	..
C. Avellana	61	58	38	46	51	38	35	43	..	27	32	71	80	..	..	56	48	3	61	42	..	80	26	(84)	..	35	51	80
O. maculata	173	..	154	166	159	165	..	138	156	156	(148)	168	..	163	156	..	168	154	..	169	..	..	..	..	..	159	167	151
I. Pseud-acorus....	163	177	142	..	159	161	..	161	156	157	157	156	..	169	156	..	171	168	165	163	166	162	172	..	(171)	159	158	131
N. Pseudo-narcissus	..	92	70	..	79	..	..	84	..	82	..	93	91	(90)	83	88	91	89	..	89	..	80	86	..	74	69	87	78
G. nivalis	..	32	..	..	(28)	(51)	(80)	39	..	29	5	..	35	50	..	.	27	37	32	17	28	33	(30)	..	26	34	35	19
SCILLA NUTANS ..	113	114	105	111	116	(119)	..	117	127	117	114	112	..	113	117	122	118	121	..	128	128	124	125	122	123	..	122	101

TABLE II.—Average Date (Day of Year) of First Flowering in each Group, 1886.

Name of Plant.	South-West of England.	South of Thames.	Central District.	Hertford-shire.	East of England.	North of England.	Ireland.	Guernsey.
Galanthus nivalis	30	42	43	32	28	30	28	19
Corylus Avellana	51	35	69	26	65	55	43	80
Ranunculus Ficaria	61	73	76	62	79	83	51	20
Mercurialis perennis	64	71	84	86	88	64	..	..
Tussilago Farfara	81	81	79	68	88	87	76	..
Petasites vulgaris	103	84	99	91	90	106	113	..
Viola odorata	77	89	84	88	81	83	..	..
Salix Caprea	92	84	87	93	89	87	81	73
Narcissus pseudo-narcissus	80	83	88	90	85	87	77	78
Ulmus montana	123	100	87	87	88	84	74	..
Draba verna	76	77	55	92	79	71	..	54
Anemone nemorosa	97	91	95	92	99	94	94	..
Caltha palustris	94	94	95	108	98	102	96	104
Nepeta Glechoma	98	103	107	108	108	119	84	115
Prunus spinosa	107	112	112	109	109	114	99	87
Primula veris	96	102	104	96	100	109	110	..
Cardamine pratensis	114	112	111	116	119	121	115	117
Stellaria Holostea	104	111	111	110	114	120	113	..
Scilla nutans	112	119	115	120	127	124	121	101
Veronica Chamædrys	106	105	125	121	121	137	126	83
Plantago lanceolata	116	124	121	125	139	125	112	94
Sisymbrium Alliaria	111	115	112	116	118	113	116	120
Syringa vulgaris	126	133	130	136	135	146	138	126
Ranunculus acris	129	127	131	112	136	141	131	107
Cratægus Oxyacantha	133	138	137	142	143	146	142	127
Vicia sepium	119	131	139	133	139	134	129	125
Æsculus Hippocastanum	123	125	127	141	130	129	129	120
Symphytum officinale	146	145	129	..	135	..	145	141
Cytisus Laburnum	136	138	136	140	142	143	139	..
Pyrus Aucuparia	141	130	140	150	141	144	141	128
Polygala vulgaris	137	133	144	155	175	154	131	40
Ajuga reptans	128	130	138	137	131	146	132	126
Geranium Robertianum	117	129	131	119	131	140	131	123
Acer pseudo-platanus	120	128	125	126	127	131	127	119
Pedicularis sylvatica	123	130	128	155	150	135	130	107
Fagus sylvatica	131	139	128	..	136	..	..	..
Galium Aparine	135	129	145	145	142	153	165	143
Euonymus europæus	153	155	162	160	155	167	159	..
Trifolium repens	155	153	154	147	150	157	150	123
Potentilla anserina	138	147	142	148	160	161	143	140
Lotus corniculatus	140	149	145	156	150	154	131	114
Chrysanthemum Leucanth.	142	149	148	149	156	174	149	174
Hieracium Pilosella	147	148	157	146	154	157	151	141
Nasturtium officinale	138	151	172	..	154	173	160	130
Lychnis Flos-cuculi	157	146	155	154	157	175	160	120
Lathyrus pratensis	158	161	167	158	165	183	148	160
Papaver Rhœas	158	166	170	156	159	166	178	..
Achillea Millefolium	175	169	175	169	184	189	176	160
Iris Pseud-acorus	160	155	160	170	164	172	163	131
Orchis maculata	160	153	162	161	169	..	163	151
Rosa canina	160	163	162	160	166	179	175	155
Daucus Carota	178	175	166	..	..	..	155	139
Cornus sanguinea	163	171	164	183	165	157	139	..
Thymus Serpyllum	174	170	168	177	172	..	202	158
Malva sylvestris	169	173	184	168	174	181	185	151
Stachys sylvatica	168	168	172	164	172	180	174	164
Epilobium montanum	166	174	167	167	174	170	173	..
Senecio Jacobæa	182	175	189	175	..	196	193	164

TABLE II.—AVERAGE DATE (DAY OF YEAR) OF FIRST FLOWERING IN EACH GROUP, 1886 —*continued.*

Name of Plant.	South-West of England.	South of Thames.	Central District.	Hertford-shire.	East of England.	North of England.	Ireland.	Guernsey.
Spiræa Ulmaria	175	180	180	174	180	188	183	..
CENTAUREA NIGRA........	181	174	175	174	175	196	188	169
Ligustrum vulgare........	168	174	178	173	187	182	173	164
Prunella vulgaris........	168	178	170	174	188	182	169	146
Vicia Cracca........ ...	172	173	184	174	176	183	177	169
Galium verum	179	179	187	183	192	192	192	158
Carduus arvensis	189	187	190	173	188	200	184	..
Hypericum tetrapterum ..	201	195	..	..	..	202	197	201
Hypericum pulchrum	183	188	186	184	..	182	..	177
Epilobium hirsutum......	192	193	195	166	196	208	205	198
Scabiosa succisa	224	188	..	..	243	..	178	..
Carduus lanceolatus	188	196	179	175	201	198	190	175
CAMPANULA ROTUNDIFOLIA	..	180	192	171	197	198	..	..
CONVOLVULUS SEPIUM	194	193	196	190	201	197	210	..
Galeopsis Tetrahit	198	184	198	..	..	205	..	..
Angelica sylvestris	221	204	..	..	167	215	..	..
Dipsacus sylvestris	197	202	..	..	..	221	..	208
Artemisia vulgaris	..	197	..	..	..	212	..	226
Sonchus arvensis	197	185	215	..	232	214	206	199
Mentha aquatica	223	217	..	..	217	227	227	221
HEDERA HELIX..........	271	266	277	..	250	..	250	255

25th, and that other spring birds arrived not more than a week late, but a better index than these summer visitors is to be found in the spring flowers, and these have not been so backward on May-day for a great number of years."

Though plants were backward, many observers remark how rapidly they came into flower when they did begin, and lasted but a very short time. Violets were "out and gone" in three weeks (Wells), and the Cowslip was out in four days in handfuls. Pilewort and Sweet Violet were very abundant (Addington), and Primroses plentiful but soon over (Buckhorn Weston). The Blackthorn was very late near Leicester, and it seemed at one time as if both Blackthorn and Whitethorn would be in flower together, but the former vanished rapidly. As was noticed at Hertford, this plant was "very partial," *i.e.* did not flower all at once as in former years.

In Guernsey, the plentiful sunshine during the last week in April made the trees come into leaf very quickly. Hedges were in full leaf everywhere, the Beech was almost in full leaf and the Elm mostly covered with young leaf. At Detling "the Wheat was backward and patchy, apparently from Wireworm. Lent corn better; Hops shot weakly, but became stronger towards the end of the month; a great deal of 'flea' was complained of. Clovers and seeds of last year's sowing also showed the dry July of last year."

At Hertford "Honey bees have not suffered so much this winter as might have been expected from its length and severity, but few stocks have been lost."

The first week of May was fine, but the weather during the rest of the month "wretched." The progress of vegetation is variously reported; as a rule it was making good progress, though the condition of the flowers was often poor and stunted. The young foliage, especially that of the Beech, was much damaged by some high winds in the middle of the month, and later on rain fell very heavily, ruining the Apple blossom and destroying the Lilac, Laburnum and Hawthorn flowers, which consequently had a singularly short existence. The leaf of the Oak was long before that of the Ash.

The observer at Addington very truly remarks that some years are especially noted for the blooming of certain flowers; *e.g.* in one year it may be the Cuckoo-flower, and another the Ox-eye Daisy; this year it has been the Dandelion; "during the first week in May they were a perfect sight in some meadows."

In Guernsey "Potatoes were dug out of doors in a few places in the second week in May, and generally in all parts of the Island by the last week. All wall-fruit set very plentifully, Strawberry bloom most profuse."

At Harpenden "the Corn crops were generally looking well, although reports were numerous of sad havoc among the Wheat plants in the lighter descriptions of soil by the ravages of the Wireworm, which was also very destructive among the young Mangold Wurzel plants, and especially was this observed to be the case in a field in the neighbourhood where a heavy dressing of night-soil manure had been applied previous to sowing the seed for the crop."

At Arboe the Swallows were falling dead from the severity of the weather and want of insect food, the Mourne Mountains being covered with snow. (A large kind of parasite *(Stenepteryx hirundinis)* sometimes attacks these birds; two of them are sufficient to cause death; in some years the Swallows have been seen to fall down in the midst of their flight and expire shortly afterwards, death being caused solely by these creatures.)

"Fly" was very troublesome in places (Lymington), and Queen Wasps still abundant; but as a rule Insect life was unusually scarce (especially Butterflies), and Aphis was hardly noticed.

"The temperature of June was variable and often of quite a winterly character, and for most kinds of vegetation very ungenial." The last part of the month was dry and hot, good for Haymaking, but very injurious to Peas and Strawberries, the crops of which failed in many places, though they promised very well at first. Haymaking began at Wells on the 9th, at Bocking on the 12th, generally about the 17th, and was in many places secured by the 30th. Wheat was in ear on the 21st at Salisbury, and on the 16th at Harpenden, at which place the cereal crops were quite a fortnight later than in average seasons.

"In many places the Onion crop was a partial failure, owing to the destructive ravages of the Onion-fly (*Anthomyia ceparum*), and in gardens of very light soil the grub of the Crane-fly (*Tipula oleracea*) was very troublesome." But Insect pests, as a rule, were not so, *e.g.* Green and Black Fly and Caterpillars; but Wasps still continued very plentiful and Queens were destroyed in quantities (Addington). At Oxford there was a marked absence of most kinds of destructive insects, "particularly those which attack the Ox-eye Daisy, the flowers of which have been unusually large, plentiful and perfect." There has also been a remarkable absence of snails and slugs.

Dog roses were quite over at Salisbury on the 22nd; at one station a large patch of the flowers of the Dyer's Greenweed (*Genista tinctoria*) had died off, as of *Lathyrus pratensis* last month. Nuts were plentiful.

During the first ten or twelve days of July the weather was fine and warm, but throughout the remainder of the month it was very unsettled, rain and very low temperatures were generally experienced, and a great deficiency in the amount of sunshine.

The Lime came into flower on the 2nd at Salisbury, on the 12th at Lymington, in full flower on the 15th at Maidstone, but did not open till the 18th near Leicester. Hay harvest only began on the 8th at Hodsock, whilst in Guernsey a second crop was secured from those fields which had been cut early. At Babbacombe it was finished by the 15th.

Aphides were not prevalent this season (at Harpenden), a few only of *Aphis rumicis* and *A. Rapæ* being noticed; but Earwigs were a great pest, several houses and gardens in that locality swarming with them. House Flies were also numerous at Cushendun and other places, but not in the houses; and as an exception to the general rule the Meadow-brown Butterfly (*E. Janira*) was abundant at Killarney.

August was a dry month and generally very good for securing the harvest, which was not entirely finished by the 31st. At Harpenden "at the time of cutting the Corn crops, they appeared to show that the ungenial and cold conditions of July had greatly deteriorated both the quantity and the quality of the grain. The ears, although large (in fact, larger ears of wheat have rarely been observed, six-set spikes being of frequent occurrence), when handled were chaffy and light and in the upper part were not fully developed." At Maidstone "the latter half of the month was favourable for harvest, but not the early part, which spoilt the Barley for malting. Roots generally were first rate; Corn was indifferent; Barley was a fair crop for quantity; Wheat was not a bright sample." In Guernsey "the Oats began to be harvested during the first week, but the crops were spoilt by the rain and wind at the latter part of July. Wheat and Barley harvest began in the second week, and the crops were very good." At Babbacombe Oats were cut on the 7th, Wheat on the 11th, and Barley on the 16th. Fruit crops generally were deficient, except Plums, which were extremely plentiful.

After the heavy rainfall of July 25th, and the succeeding fine days of August, Potato disease began to manifest itself at Harpenden, but not of so serious a nature as in some previous years; with this exception the country seems to have been pretty free from the disease.

At Salisbury the flowers of the common Poppy were abundant, but unusually small. The scent of the fragrant flowers, especially Sweet Pea, Mignonette and Magnolia, was less powerful than usual; "a flower of Magnolia is generally too strong to be borne in a sitting-room; this year one remained in a small sunny room and its scent was scarcely noticed."

At the end of August the Turnip Aphis (*A. Rapæ*) began to be more prevalent among the Cabbage and Turnip crops at Harpenden. Wasps were generally very scarce, only one was seen all the year at Salisbury (on August 27th), but at Maidstone they were seen every day to the end of the month. A few nests only were seen in one or two localities.

Swallows began to flock at Hodsock on the 23rd.

September was a dry month; fine for the first three weeks, but unsettled towards the end. Autumn tints were scarce, Beeches only appeared tinted when seen near; the Lime alone had decidedly changed, and by the end of the month these trees were perceptibly thinned. Harvest was generally over by the end of the third week, but by this time shrubs and flowers were drooping for want of rain at Lymington and other places.

At Detling, during the latter part of August and the first part of September, the hot suns and foggy nights sadly damaged the Mid-Kent Hops, turning the cones to a reddish brown and rendering them for the time quite unsaleable. North and East Kent escaped better. The harvest was over by the middle of September, but was by no means satisfactory; not much Barley was bright enough for malting; many Oats heated in the stacks, and Wheat was considerably blighted and never looked bright when standing. "Fruit was plentiful, except Apples, which were short in quantity, but well grown out; Plums were a perfect drug in the market, and Damsons only fetched 1s. 6d. to 2s. a sieve, when they have made 8s. to 10s. in former years. Hay was about £4 10s. a ton, and scarce on the Chalk Hills (some 8 acres to a ton), but there was a large crop in the Weald of Kent. Some pieces of Mangold were good; while Swedes were small."

At Wells, Apples and especially Pears were very abundant in gardens, but not in orchards. Several orchards were without an average crop on a single tree, and the majority were bare of fruit. Carrots, Turnips and root vegetables generally were good. Blackberries were late but very abundant.

At Lymington the larvæ of the White Butterflies (*P. Brassicæ* and *P. Rapæ*) were abundant, and roots in the field were covered with mildew and flies.

The Report, therefore, as a whole is not a satisfactory one. The weather has been very ungenial and everything much retarded, though, on the other hand, it has been very fatal to insect life, the complaints of their ravages having been far less than usual.

Bush fruits were very abundant, but stone fruits, except Plums, were not so. Strawberries and Peas were spoilt by drought in many places; Plums were extraordinarily plentiful, the cost of picking and carrying often being more than they realised in the market; Apples were very poor, from the destruction of the bloom by heavy rain. Hay was good and plentiful and well harvested; Corn and other grain were up to an average; root crops were, as a rule, remarkably good.

ENTOMOLOGY.

The Entomological Report is much more instructive than usual. Notwithstanding the long, cold spring, insects were certainly not much behind their usual times, and in some instances were earlier than last year. There are, naturally, some extremes, but they will be noticed under the different species. The dates from Strathfield Turgiss are singularly late, and those from Cardington and Harpenden as singularly early, especially with respect to the Butterflies. Some of the dates seem far too early, but no specimens are sent.

The following Table will give at a glance the comparison between this year and last. In the first column are the average dates for all localities; in the next two columns the averages for the same places in the two years, which may possibly give a more correct idea:—

		In same places		
	Average 1886.	Average 1885.	Average 1886.	Difference.
Cockchafer	142	139	143	+ 4
Bloody-nose Beetle	108	82	96	+ 14
Glowworm	173	170	176	+ 6
Large White Butterfly ...	117	116	117	+ 1
Small White Butterfly ...	114	107	116	+ 9
Orange Tip Butterfly ...	131	136	131	− 5
Brimstone Butterfly ...	83	110	83	− 27
Meadow Brown Butterfly ...	160	154	151	− 3
Frog Spawn	72	61	70	+ 9

The Cockchafer appeared toward the end of May, and only about 4 days later than last year. At Buckhorn Weston it was 27 days late, at Strathfield Turgiss 23 days late, at Killarney 16 days late, but at Addington 22 days early.

Bloody-nose Beetle.—But very few notices of this insect have been sent in. Of the three places for which dates occur for the two years, at Strathfield Turgiss it was no less than 36 days late, at the other places only one and four days late.

Glowworm.—Only three comparisons between the two years can be made. At Buckhorn Weston it was 33 days early, Westward Ho 50 days late, and at Strathfield Turgiss one day early. These returns cannot be considered as conclusive.

The Honey Bee appeared at Salisbury and Marlborough in February, doubtless on one of the few bright days, but elsewhere the dates range from March 18th to 26th (average March 20th), showing that as soon as the warm weather set in, the Bees began to work.

Wasps were seen as early as February 8th at Marlborough, but probably only on a fine day. They were very abundant in the first half of April, and the extraordinary number of Queen Wasps has been noticed in the General Report. In the autumn but very few, as a rule, were seen.

The Large White Butterfly appeared very nearly about its proper date, and only one day later than last year. At Cardington it was 30 days earlier, and at Wicklow 25 days later. It would be very desirable to have further confirmation of these exceptions.

TABLE III.—INSECTS AND FROG SPAWN.

Stations.	Cock Chafer.	Bloody-nose Beetle.	Glow-worm.	Honey Bee.	Wasp.	Large White.	Small White.	Orange Tip.	Brimstone.	Meadow Brown.	St. Mark's Fly.	Frog Spawn.	Tadpoles.
Babbacombe	..	..	..	..	..	..	115	..	..	..	..	..	..
Buckhorn Weston	129	75	183	80	112	115	102	124	83	156	..	63	155
Westward Ho	142	..[1]	174	..	102	123	114	117	..	170	.	..	..
Tidenham	..	..	..	80	..	..	..	..	..	..	..	..	..
Usk	141	..	..	80	117	125	114	120	83	187	141	..	156
Salisbury	..	..	..	43	(239)	114	116	146	102	..	..	82	..
Marlborough	127	147	163	42	39	126	..	126	..	176	..	..	..
Pennington	..	..	177	..	..	..	..	..	..	182	..	..	..
Strathfield Turgiss	144	130	170	77	91	150	137	142	..	171	148	91	..
Maresfield	..	..	..	..	..	..	83	..	..	..	..	..	..
Lewisham	..	..	..	78	..	..	..	..	..	..	..	..	..
Detling	..	..	..	77	93	..	114	129	83	..	118	..	..
Ealing	..	..	..	85	..	..	112	..	..	(192)[2]	..	85	..
Oxford	..	..	..	79	79	124	117	..	78	..	..	..	..
Addington	140	..	..	..	80	..	116	124	83	..	..	84	..
Cardington	..	..	..	78	109	79	105	..	..	117	..	..	..
Northampton	163	..	..	80	87	..	113	155	..	..	..	..	..
Thurcaston	..	..	..	(119)	44	..	109	..	..	..	..	..	..
Harpenden	148	82	..	76	28	87	114	122	..	122	..	85	..
Hertford	109	..	..	2	..	109	..	119	..	..	..	83	..
Ware	..	..	..	2	..	..	..	..	..	..	..	..	..
Wickham	..	..	..	..	94	..	..	..	..	..	...	83	..
Belton	157	..	..	78[3]	..	125	118	150	..	..	..	..	..
Tacolneston	..	..	..	..	80	102	..	125	81	..	..	..	..
Hodsock	..	..	..	..	99	..	..	..	..	..	..	82	115
Hampson	..	..	..	..	81	..	..	..	..	..	..	82	..
Arboe	..	..	..	..	105	..	..	117	..	..	..	..	..
Cushendun	..	..	..	..	107	..	..	142	..	..	..	..	..[4]
Killarney	156	..	..	..	51	..	(126)	139	..	..	..	41	..
Wicklow	186	..	..	..	..	142	115	126	..	..	..	84[2]	..
Guernsey	105	..	..	..	..	112	106	..	..	..	113	17	46

[1] Larva 87. [2] "May have been earlier." [3] One on 17th. [4] Tadpoles at Pomeroy in two different places in August.

The Small White Butterfly generally appears before the Large White, this year it was only one day earlier, but nine days later than last year. At Buckhorn Weston it was 52 days late, and at Strathfield Turgiss 28 days late. If these exceptions are omitted, the average dates for last year and this would be 112 and 115.

The Orange Tip Butterfly was from three to four weeks early at Westward Ho, Marlborough, Detling and Harpenden; these large differences make the average five days earlier than last year.

Brimstone Butterfly.—The date for Salisbury is rather late, but omitting this, it is interesting to notice again how the change in March affected animal life. It was first noticed at Detling last year on April 20th, which is the only date for comparison.

The Meadow Brown Butterfly was 19 days late at Strathfield Turgiss, and 86 days early at Harpenden; all other dates only vary about seven days.

Frog Spawn was observed in Guernsey as early as January 17th, at Killarney on February 10th, at Buckhorn Weston March 4th, and elsewhere about March 25th. This again shows the effect of the change in March. At Guernsey it was three weeks earlier than last year, and at Salisbury as much as 39 days later. The general retardation varied from 2 to 18 days in other places.

ORNITHOLOGY.

SONG.—The same remarks as were made about insects apply to the early songsters. One or two began as early as January 1st, but they ceased as soon as the cold weather returned, and did not sing continuously till the middle of March. The dates are necessarily very variable, but it will be seen that on the average they were decidedly later than usual. As regards the other birds, the Nightingale was only one day later than the average, the Willow Wren 4 days, and the Chiff-chaff 13 days, whilst the Cuckoo was 2 days earlier.

The Nightingale was frequently seen before it was heard, as has been observed in previous years, and some dates have been reported, though such dates have not been entered, unless the observer could state that they were supplied by competent authorities. It was reported at Geldeston, April 3rd, heard at Norwich April 7th, but was not seen at Hodsock till May 8th. Its general appearance was during the latter half of April.

The early average date of the Cuckoo for 1886 was due to its appearance as early as March 25th at Cushendun in Ireland; it was seen there again on April 3rd and heard April 11th. It was heard at Sittingbourne, in Kent, on April 10th, and during the next fortnight was heard all over England (Tunbridge Wells April 25th, Leicester April 27th).

MIGRATION.—The scanty notices of some of the species render any deductions from them very unsafe, but as far as migration in general is concerned, birds were, if anything, rather earlier than usual. The Fly-catcher was 2 days later than the average, but the Wheatear 14 days earlier. The Swallow tribe were also early. Swallows were seen first at Usk on March 29th, reaching Durham by April 29th; they were not noticed at Babbacombe till May 5th.

The Martin was seen first at Westward Ho as early as March 28th, but not till May 13th at Strathfield Turgiss: it seems to have been very irregular in its appearance, if the dates given are correct. It was not seen in Guernsey till May 11th.

The Swift was seen first at Buckhorn Weston on April 20th, and at Cushendun April 26th; at Babbacombe not till May 19th, and at Durham not till June 19th. It was not reported as being seen till May 31st at Tacolneston, but the bird must have escaped observation.

The Corncrake was still more irregular in its appearance. It was seen at Marlborough on April 22nd, and in Wicklow on April 24th, but not at Strathfield Turgiss till June 30th. There seems to be no regular series of dates for determining the direction of migration.

The returns do not appear to shed much light on the subject of Phenology: it is quite possible that the alternations of cold and fine weather

TABLE IV.—BIRDS.

Station.	SONG.									MIGRATION.									NESTING.						
																			Song Thrush.				Rook.		
	Brown Owl.	Song Thrush.	Nightingale.	Willow Wren.	Chiff-chaff.	Skylark.	Chaffinch.	Cuckoo.	Turtle Dove.	Flycatcher.	Fieldfare.	Wheatear.	Swallow.	House Martin.	Sand Martin.	Swift.	Goatsucker.	Corncrake.	Nesting.	Eggs.	Young.	Chaffinch. Eggs.	Building.	Young.	Partridge.
Babbacombe	..	..	..	..	..	..	..	114	105	..	..	..	125	..	..	139	..	..	..	..	..	..	..	..	..
Buckhorn Weston	..	32	..	98	..	79	82	106	..	157	344	..	110	102	..	110	..	127	92	..	110	..	33	..	..
Westward Ho	..	..	..	148	80	..	..	..	..	..	..	..	92	87	..	126	..	..	91	..	..	..	75	..	149[1]
Usk	..	..	116	88	..	..	..	108	..	112	..	..	88	128	88	126	..	119	..	..	..	124	..	..	..
Salisbury	..	43	..	..	..	57	..	102	..	..	..	..	99	100	98	..	..	146	..	..	..	..	63	..	..
Marlborough......	..	..	125	..	..	..	..	114	..	108	..	..	101	115	..	..	..	112	..	(4)	102	119	37	109	..
Strathfield Turgiss	..	31	113	121	130	45	54	111	117	141	..	92	105	133	..	134	171	181	..	77	..	..	63	114	29[2]
Wellington College	..	..	..	..	..	68	..	..	..	..	..	83	..	..	..	..	..	..	..	..	..	..	74	..	..
Maresfield........	..	..	..	..	..	..	..	107	..	..	..	..	101	106	..	..	..	..	..	..	..	..	..	..	114[3]
Tunbridge Wells..	..	..	..	..	..	..	..	115	..	..	..	..	..	113	..	..	..	..	..	..	..	..	..	..	..
Detling	..	..	107	..	..	..	82	102	..	..	..	..	103	109	..	131	133	..	..	..	..	..	..	..	..
Ealing	..	..	..	..	..	33	..	122	..	..	..	..	116	126	..	126	..	..	..	..	..	..	..	..	..
Oxford	..	..	..	..	..	36	..	..	..	142	..	..	..	..	..	126	..	123	..	91	..	..	85	..	..
Addington........	..	..	126	..	..	..	..	111	..	..	..	..	110	..	..	131	..	..	82	92	..	..	..	..	124[3]
Cardington	..	77	117	..	105	77	88	115	..	153	..	..	113	..	..	..	..	139	..	..	..	..	..	121	..
Northampton	..	50	116	..	..	69	..	116	..	..	..	..	99	114	106	126	..	145	..	..	..	..	67	96	..
Harpenden	108	(7)	115	..	..	32	..	112	..	..	..	..	108	115	..	128	..	115	..	..	..	..	71	..	..
Hertford	..	(1)	105	..	..	(1)	..	105	..	..	..	..	91	..	..	..	..	..	..	..	..	..	71	..	..
Bocking..........	..	..	117	..	..	..	..	113	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Belton	46	(2)	113	119	..	76	58	114	..	120	..	..	102	125	124	126	..	124	91	..	103	..	73	..	43[4]
Tacolneston	..	..	117	..	..	..	..	116	..	..	..	..	113	123	..	(151)	..	..	82	..	..	..	80	..	..
Hodsock	..	..	128	111	..	..	..	120	..	..	..	..	112	115	111	128	144	124	87	..	..	128	..	120	125[3]
Hampson	..	33	..	..	..	55	52	..	..	..	..	..	..	..	..	..	..	..	83	93	..	..	66	..	..
Durham..........	..	47	..	117	119	44	..	..	..	188	..	..	119	..	116	170	..	..	..	111	..	..	74	..	120[3]
Arboe............	..	33	..	..	..	39	18	102	..	..	..	..	97	..	..	126	..	116	..	..	..	..	..	..	..
Cushendun	..	28	..	100	..	..	..	101	..	..	..	..	95	..	..	116	..	118	..	..	..	..	..	..	..
Killarney	..	34	..	103	96	42	36	125	..	..	..	..	(106)	115	..	..	..	..	..	..	..	..	(61)	153	..
Wicklow	..	..	..	99	102	82	..	120	..	..	..	82	103	97	..	126	..	114	..	..	..	..	86	..	..
Guernsey	..	..	..	..	..	17	..	109	..	..	..	..	112	131	..	..	..	123	..	..	..	..	..	..	..
Average......	..	41	117	110	105	53	59	112	111	140	..	86	105	114	107	129	149	128	87	93	105	124	68	..	..

[1] Nesting. [2] Pairing. [3] Eggs. [4] Calling.

influenced both observers and observed, and as there can be no means of judging how long a bird may have been in England before being seen (as there is of deciding how long a plant may have been in flower), it requires a very large series of observations to correct these irregularities.

Nesting.—The notices have been scanty—the only two species about which any special remarks need be made are the Song Thrush and Rook. The former often begins to lay very early in the year, and at Marlborough eggs were found as early as January 4th; but omitting this, the bird wisely deferred laying till the warm weather set in, and, as a rule, it waited till the beginning of April, about a week later than the average. The Rooks made attempts at building very early in the year, but were soon checked by the cold. At Buckhorn Weston and Marlborough they are considered to have commenced building operations early in February, but the majority of observers do not consider that nesting really began till after the middle of March.

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE BRITISH MILITARY CEMETERY, SCUTARI, CONSTANTINOPLE, 1866–1885.

By WILLIAM H. LYNE.

(Communicated by R. H. Scott, M.A., F.R.S., F.R.Met.Soc.)

[Read December 15th, 1886.]

The Military Cemetery, Scutari, is in lat. 41° N; long. 29°·8 E. The instruments are 60 ft. above sea-level, and 90 ft. from the face of the cliff overlooking the Sea of Marmora.

The extreme elevations and extreme depressions generally come on gradually,—the latter often ending with a sharp fall, followed by as sudden a rise. The elevations occur just before or during fine, clear or frosty weather, though there are exceptions. The depressions are the precursors of squalls chiefly from the South-south-west and West, veering to North-west and North, followed by rain, sleet, snow and frost in Winter; and of thunderstorms with rain, followed by bright, clear, and comparatively cool weather in summer. A low barometer, indicating an approaching storm, often happens, but no local disturbance takes place. Sheet lightning and heavy cloud banks on the horizon show, however, that a storm has occurred at no great distance; after which the air becomes clear, cool and refreshing.

The maximum and minimum and the dry and wet bulb thermometers are on a "Glaisher's" stand, the bulbs about 4 ft. from the ground.

The black-bulb *in vacuo* rarely reaches 150°. The radiation thermometers are set on forks, about 2½ ins. above the surface of the ground.

TABLE I.

BAROMETER, CORRECTED AND REDUCED TO SEA-LEVEL FROM OBSERVATIONS AT 9 A.M. AND 3 P.M. 1866–1885.

Month.	Mean.	Extremes.					
		Highest.	Day.	Year.	Lowest.	Day.	Year.
	Ins.	Ins.			Ins.		
January	30·111	*30·695*	28	1880	29·291	14	1881
February	30·089	30·662	14	1867	29·281	22	1870
March	29·950	30·606	4	1872	29·093	12	1883
April	29·917	30·378	15	1880	29·366	4	1869
May	29·924	30·243	2	1881	29·505	8	1874
June	29·885	30·268	2	1874	29·530	8	1871
July	29·856	30·182	6	1870	29·426	27	1878
August	29·875	30·228	31	1871	29·409	1	1879
September	29·969	30·342	27	1875	29·502	1	1873
October	30·018	30·454	14	1877	29·495	2	1871
November	30·033	30·491	14	1867	*29·036*	21	1874
December	30·075	30·625	6	1869	29·338	15	1866
Year	29·975	..	..	..	..	..	..

TABLE II.—TEMPERATURE, 1866–1885.

Month.	Mean of Max. and Min.	Extremes.						Means.	
		Highest.	Day.	Year.	Lowest.	Day.	Year.	Black Bulb.	Minimum on Grass.
	°	°			°			°	°
January	41·9	65·0	10	1872	*13·0*	25	1869	72·5	32·4
February	41·9	73·2	25	1879	15·6	6	1874	81·8	31·9
March	46·4	79·4	23	1877	16·5	14	1880	96·2	34·8
April	53·7	86·6	12	1879	26·6	3	1868	112·6	40·0
May	62·6	91·6	31	1883	36·8	5	1878	125·6	51·8
June	70·5	*103·6*	22	1869	44·0	4	1882	133·5	54·7
July	75·7	102·4	6	1879	53·6	11	1867	139·0	59·4
August	75·7	103·4	2	1880	53·0	16	1867	137·4	59·7
September..........	69·7	100·4	1	1878	39·4	26	1875	126·5	55·0
October	62·7	95·8	5	1883	29·0	20	1866	109·3	49·5
November	53·2	83·4	2	1881	26·8	23	1866	81·9	42·2
December	46·6	70·6	5	1871	19·0	29	1879	75·3	36·9
Year	58·4	..	..	..	..	..	..	107·6	45·7

Frost occasionally occurs in November, but rarely in October. In December it is sometimes, but not often, severe. The most severe frosts come in January, February and March. Frosty nights sometimes occur in April, but not after the middle of the month.

Some winters pass with very little frost, and with little or no snow; others, on the contrary, are severe—notably that of 1879-80. From December 1st, 1879, to March 31st, 1880, there was frost on sixty-three nights, on fourteen of which the frost exceeded 10°, and twenty-nine on which it exceeded 5°. The mean temperature of January 1880 was nearly 9° below the mean of the twenty years covered by the foregoing Table. The mean temperature of

January 1886 was 8° above the average of the preceding twenty years. And to day (February 24th, 1886) we have Geraniums and other half-hardy plants in the open ground, where they have stood for nearly two years, in a healthy state, and some of them still flowering.

During our most severe winters there are many fine warm sunny days, the changes from heavy snowstorms and frost to clear bright warm sunshine, or in other words from blighting cold to almost summer heat, being very sudden and often unexpected. In some winters there are three or four recurrences of this kind, at intervals of more or less length. This renders the climate of Constantinople very trying to delicate constitutions, especially so to those suffering from pulmonary affections; and necessitates, during at least six months of the year, great care and circumspection.

I am induced to make these remarks because numbers of Englishmen and women, travelling either for pleasure or health, are under the impression that frost and snow and raw bleak weather are unknown in Constantinople. All in search of a balmy health resort should avoid this place during Winter, and even in the early Spring and late Autumn periods, for the changes of temperature and humidity from the end of September to the beginning of May are so sudden that the climate during that time might be not unfairly termed treacherous.

The fine weather period from May to September is generally dry and healthy, and the temperature more equable.

TABLE III.—HYGROMETRICAL RESULTS, WIND, CLOUD AND RAIN, 1866–1885.

Months.	9 a.m.			Daily Movement of Wind.	9 a.m. and 3 p.m.		Rainfall.	
	Dew-point.	Elastic Force of Vapour.	Relative Humidity.		Clear Days. 0 to 3 of visible sky.	Overcast. 8 to 10 of visible sky.	Amount.	No. of Rainy Days.
	°	In.		Miles.			Ins.	
January	36·4	·215	83	194	5·7	18·2	3·31	16·8
February	36·2	·214	82	185	5·2	16·2	2·45	14·3
March	40·5	·252	79	176	6·6	17·7	3·19	15·6
April	46·6	·318	75	134	10·1	11·4	1·47	9·9
May	54·5	·426	72	112	13·2	8·5	1·35	6·8
June	60·6	·530	67	104	16·9	5·0	1·72	6·3
July	64·2	·600	63	116	19·6	3·0	1·15	3·9
August	63·7	·590	63	119	18·2	3·6	1·77	6·4
September	59·6	·511	66	170	15·2	5·8	2·22	7·1
October	55·2	·436	75	130	10·0	12·0	2·77	10·6
November	47·1	·324	80	108	7·5	15·0	3·69	14·2
December	41·0	·256	80	200	6·1	17·6	4·20	16·7
Year	50·5	·389	74	146	11·2	11·2	29·29	128·6

The means of the Dew-point for each month have been worked out from the daily record, and the Elastic Force of Vapour corresponding to the result taken from Glaisher's Tables.

Owing to the relatively low position of the Observatory, the shelter afforded by trees, and the buildings of the neighbouring Turkish Military Hospital, the movement of the wind is much less (by estimation about 60 or 70 per cent. in Summer and 40 or 50 per cent. in Winter) from all Northerly and Easterly directions than would be recorded in a freely open position.

Gales of 40 miles per hour hardly ever occur. The movement during our strongest winds seldom exceeds 30 miles per hour for any considerable length of time. A steady blow of from 20 to 30 miles per hour is not infrequent. The full force of the heaviest squall on record was 72 miles per hour—lasting only ten minutes, and then decreasing to 40 miles per hour.

The prevailing Winds are North-east and North, South-west and South. And oftentimes there are two or three upper currents, as shown by the movement of the clouds, crossing each other in different directions.

TABLE IV.—TEMPERATURE OF THE SEASONS IN FIVE YEAR PERIODS FOR THE 20 YEARS 1866–1885.

Years.	Winter.	Spring.	Summer.	Autumn.	Years.	Winter.	Spring.	Summer.	Autumn.
	°	°	°	°		°	°	°	°
1866	41·2	55·1	72·5	58·1	1876	41·7	55·6	74·2	61·9
1867	43·9	52·6	70·2	58·9	1877	46·7	56·0	72·4	62·3
1868	41·7	51·8	73·8	62·5	1878	42·8	54·9	74·1	65·3
1869	42·0	55·7	74·9	61·3	1879	50·0	57·4	76·8	62·3
1870	44·7	52·8	73·2	60·1	1880	38·4	50·4	75·3	63·2
	42·7	53·6	72·9	60·0		43·9	54·9	74·6	63·0
1871	45·9	53·0	75·0	62·2	1881	42·1	53·7	73·7	61·3
1872	43·5	57·3	72·9	65·5	1882	40·2	54·3	74·6	62·1
1873	48·5	57·1	73·6	61·9	1883	41·6	53·5	75·9	64·5
1874	41·5	52·5	73·6	63·1	1884	41·9	54·4	72·0	58·6
1875	45·3	51·2	75·2	59·7	1885	44·0	55·5	75·6	64·0
	45·0	54·2	74·1	62·5		41·9	54·3	74·3	62·1
					Means	43·4	54·2	74·0	61·9

The Winter comprises the months December, January, February; Spring—March, April, May; Summer—June, July, August; and Autumn—September, October, November.

The greatest fall in one day was 4·06 ins. on September 25th, 1866.

During the seven months May to November 1863, only 4·17 ins. of rain fell. Numberless fruit trees died, and plants of every kind suffered more or less from the long drought.

In 1879 no rain fell from May 19th to September 2nd, but during the next four months 18·25 ins. fell. which brought the total rainfall of the year up to more than the average amount.

Although the rainfall is very irregular, it will be seen from the foregoing Table that a series of dry years and of wet years follow each other with remarkable regularity.

TABLE V.—RAINFALL FOR THE TWENTY-FOUR YEARS, 1862–1885. GAUGE 6 INCHES ABOVE THE SURFACE OF THE GROUND.

Year.	Rainfall.	No. of Rainy Days.	Year.	Rainfall.	No. of Rainy Days.	Greatest Fall in one Month.			
						Month.	Amount.	Date.	Year.
	Ins.			Ins.			Ins.		
1862	[1]23·30	124	1874	24·77	113	January	6·89	23	1881
1863	14·78	103	1875	42·74	163	February	4·25	17	1874
1864	30·87	148	1876	30·18	122	March	6·12	20	1875
1865	31·12	141	1877	39·43	160	April	4·38	15	1878
1866	40·37	127	1878	34·55	136	May	3·77	15	1871
1867	30·89	122	1879	31·41	137	June	3·64	7	1880
1868	36·73	127	1880	22·33	118	July	3·70	3	1876
1869	21·31	122	1881	25·76	137	August	5·80	6	1868
1870	30·04	131	1882	20·42	108	September......	6·37	8	1866
1871	28·90	142	1883	29·55	155	October	8·67	21	1866
1872	23·21	107	1884	28·10	141	November	7·00	14	1877
1873	24·27	99	1885	19·38	120	December	10·35	21	1862

Average Rainfall of 23 years, 28·75 ins. No. of Rainy Days, 126.

[1] January and first week of February not included.

AN ANALYSIS OF

FORTY YEARS' CONSECUTIVE OBSERVATIONS OF STORMS IN THE COUNTY OF SUSSEX.

By CHARLES LEESON PRINCE, F.R.MET.SOC., F.R.A.S.

(Plate II.)

THE occurrence, or non-occurrence, of gales at the periods of the equinoxes over the British Isles, has lately been under consideration among scientific men, and the time-honoured idea undoubtedly obtains, with a large section of the community, that these storms arrive at the seasonal time with a fair amount of regularity, and to hold the contrary opinion would be generally considered absurd. My attention was given more immediately to this subject upon reading the paper by Mr. Scott, F.R.S., which appeared in the *Quarterly Journal of the Royal Meteorological Society*, Vol. X. p. 286.

I must confess, that upon the outset of my inquiry, I was somewhat imbued with the popular idea; but as I was anxious to test the matter by the inexorable logic of facts, and as Mr. Scott's paper referred to fourteen years only, I determined to examine all my own manuscript journals for the forty years ending December 31st, 1885, from which I considered it possible, on account of the much longer period, to obtain a more reliable statistical account of the diurnal, monthly, and yearly prevalence of gales over the south-east of England, and particularly at, or about, the two equinoxes. I trust, too, that as all the estimations of force have been made by myself, the question of personal equation need not be entertained.

I commenced my investigation by collecting, and then subdividing into three classes, all recorded instances of markedly strong winds : thus, *a* would be notices of simply stormy or boisterous weather; *b*, actual gales, respecting the force of which there could be no doubt whatever; and *c* would denote the most severe gales, during which, at intervals, the wind blew with the force of a hurricane, as evidenced by the unroofing of houses and uprooting of trees. As a brief summary, I will at once state that during the forty years I have recorded very stormy weather on 358 days ; actual gales on 327 other days ; and hurricanes on other 44 days; making altogether 729 instances of various atmospheric disturbances; to which statement I will append tables of the several details of what occurred in my immediate neighbourhood ; and I have also added a diagram (Plate II.) of the distribution of storms, suggested, and kindly executed, by Mr. G. J. Symons, F.R.S.

It is not only possible, but very probable, that in many instances wherein I have recorded merely boisterous weather a severe gale might be passing at some inconsiderable distance outside the county of Sussex, so that the dates of actual gales upon my list will not always coincide with others which may have occurred at the western or northern parts of the kingdom.

The number of gales mentioned by Mr. Scott, in his fourteen-year period, exceeds those recorded by me for corresponding years; but this I imagine will be fully accounted for by the fact of his including in his list any which may have been reported from any part of England, Scotland, or Ireland, while mine is a strictly local record. With respect to the question of periodicity of gales over these islands, I think that a glance at Table III., which gives their diurnal and monthly frequency, will be sufficient to satisfy the most sceptical of their non-prevalence, either at the equinoxes or at any other well-defined period. If we take the several calendar months, the nearest approach thereto is the great concentration observable in the latter part of October, viz. from the 22nd to 29th both inclusive; but if we take the last four days of December and first four days of January, we shall find a total of twenty-five, *i.e.* exceeding the October period by one.

As to equinoctial periods, these are remarkable only for the very partial occurrence, or entire absence of gales.

Boisterous weather is frequent during the third week in March, but not in the corresponding week of September, and as regards the total number of gales for the several months, March appears as the sixth in order upon the list, and exceeds that for August by only nine instances.

I think it will be found stated in some meteorological works that November has had the character of being the stormiest month of the year, which my analysis will certainly contradict; nevertheless, I believe it to be a fact that some of the worst gales on record have occurred in this month, that of 1836 being the earliest impressed upon my memory.

Upon referring again to Table III. it appears quite evident that the maximum of atmospheric disturbance occurs in January and December. The latter month records one hurricane more than January, but January had seven more gales than December. Next in order of gradation of frequency comes October, and then February, November, March, August, September, May, April, June and July.

As regards diurnal frequency the 2nd and 26th days have the largest number, but, upon the whole, gales are found to be distributed much more equably throughout the year than could have been supposed without statistical proof.

We may now assert that gales at the period of the equinoxes are more the exception than the rule.

TABLE I.

The following statement gives the dates of prevalence of stormy weather, gales, and hurricanes, respectively, between January 1, 1846, and December 31st, 1885:—

An asterisk denotes a gale. An asterisk with ! denotes a hurricane.

1846.—Jan. 22, 25; March 16*; May 18; July 18*; Oct. 5,* 6,* 7,* 10,* 15,* 21*; Nov. 20; Dec. 21.*

1847.—Jan. 24,* 28*; Feb. 18; April 9; June 15; Sept. 10, 19*; Oct. 23*; Nov. 17, 23; Dec. 6,*! 9.

1848.—Jan. 17*; Feb. 9, 24,* 25,* 27*; March 11*; June 3; Oct. 9,* 25; Nov. 20,* 29; Dec. 2, 4,* 5,* 6,* 7,* 8.

1849.—Jan. 11,*! 14; Feb. 28*; March 25*; April 19*; Oct. 3*; Dec. 17,* 18,* 28.*

1850.—Jan. 14,* 15*; Feb. 5,*! 6*; April 9, 15, 16; Oct. 7, 23*; Nov. 4,* 19, 24*; Dec. 15.

1851.—Jan. 15, 16,* 17, 20*; March 18, 19, 22*!; June 9; July 14; Oct. 1, 2, 3.

1852.—Jan. 3, 11, 12, 15,* 24; Feb. 4, 8*; May 11, 12; Aug. 11*!; Oct. 26,* 29*; Nov. 7,* 17, 23, 28; Dec. 27.*!

1853.—Jan. 7,* 12*; March 31; April 1, 3; Sept. 26; Oct. 17.*!

1854.—Jan. 3,* 8, 24,* 27; April 23*; May 7, 28, 29; Sept. 14; Dec. 5,* 18.

1855.—Jan. 31*; Feb. 3*!; March 3, 12, 17, 21; Oct. 4, 5, 6, 26*; Dec. 24, 26!

1856.—Jan. 24; Feb. 6, 7; April 3, 9, 15*; May 18*!; Aug. 21; Sept. 22, 23, 28; Dec. 7, 10, 12.

1857.—Jan. 1, 3, 9; March 9, 14, 15, 30; Oct. 7, 8.

1858.—March 6,* 7*; April 5; May 1, 16, 17; July 25*!; Aug. 21; Sept. 23.

1859.—Jan. 23*; March 12, 13, 14; April 9; Sept. 17*; Oct. 26,*! 28, 31*; Nov. 1,* 5, 6*!; Dec. 25, 29.

1860.—Jan. 23,* 24; Feb. 28*; March 21,* 31*; April 1, 2, 18; May 28*; June 2,*! 3; Aug. 18, 24,* 25, 29*; Sept 24*; Oct. 16, 18; Nov. 14, 21; Dec. 26,* 30.*

1861.—Feb. 21*; March 1,* 2,* 12, 17, 20, 21; July 24; Sept. 23; Nov. 26.

1862.—Jan. 11; March 7, 9; April 2,* 23; June 6, 11,* 12, 13, 14; Aug. 7,* 8*; Oct. 17,* 19,* 22*; Dec. 21,* 29.

1863.—Jan. 2,*! 5,* 20*!; May 19; June 10*; July 2; Aug. 31*; Sept. 20; Oct. 30; Nov. 2,*! 4, 5; Dec. 2,* 3.*

1864.—March 7, 10, 11, 29; April 1; Oct. 22, 23*; Nov. 13, 14, 17, 25.

1865.—Jan. 14; Feb. 18; August 15; Oct. 29*; Nov. 21, 22*; Dec. 29,*! 30.*!

1866.—Jan. 2,* 7,* 8,* 9,* 10,* 11,* 13*; Feb. 2, 3, 7, 9, 11*!; March 23*; Aug. 6; Sept. 5, 9, 11, 16, 20; Nov. 16; Dec. 4, 5, 6, 7, 13, 26.

1867.—Jan. 6, 7,*! 8, 9; Feb. 4, 5, 6,* 8; March 18*; April 8,*! 11, 13, 14,* 21; Oct. 27.*

1868.—Jan. 18,*! 31; Feb. 1,* 2, 3, 29; March 11*; April 19; Aug. 22*; Sept. 27, 28, 29,* 30*; Oct. 24*; Nov. 3,* 22*; Dec. 4, 5, 6,*! 11,* 15,* 24, 27, 28.*

1869.—Jan. 3,* 5,* 31*; Feb. 7,* 8,* 12*!; June 15*; Aug. 3*; Sept. 12,* 13,* 18*; Dec. 15,* 16.*!

1870.—Jan. 8*!; Feb. 2, 12,* 13*; March 4; May 12, 13, 14; Sept. 2, 9; Oct. 8, 12,* 13,* 16; Nov. 22*, 23; Dec. 11.

1871.—Jan. 16, 17; Feb. 5,* 10,* 27*; March 6, 13; April 15, 16; July 4; Aug. 24; Sept. 27*; Oct. 29*; Dec. 20.*

1872.—Jan. 1, 4,*! 7, 17,* 23, 24*; March 18, 27,* 28*; April 21,* 23; May 4,* 6, 7, 8, 17*; Aug. 9,* 10,* 11; Sept. 27*!; Oct. 10,* 24,* 26, 29*; Nov. 1,* 6, 10,* 15, 24,* 26*; Dec. 5, 8,*! 16, 22,* 25,* 31.*

1873.—Jan. 1,* 4,* 6, 13, 18,* 22; Feb. 2, 25*; March 9,* 19; April 10; July 13*; Aug. 12, 28*; Sept. 9,* 10; Oct. 10,* 11,* 12,* 23; Nov. 1,* 2, 29*; Dec. 15,* 30*.

1874.—Jan. 1,* 15,* 18,* 20; Feb. 13,* 14, 26*; March 28,* 29*; April 2,* 4,* 13; Aug. 9, 10, 13, 14; Sept. 11*; Oct. 6,* 21,* 25; Nov. 29*; Dec. 6,* 8,*! 11,* 16.*

1875.—Jan. 1,* 19,* 23,* 24*; March 5, 7; June 13,* 14, 15; July 11*; Sept. 26*; Oct. 3,* 26*; Nov. 5,* 14,* 19; Dec. 21,* 22.*

TABLE I.—*Continued.*

1876.—Jan. 13; Feb. 21; March 3, 8,* 12,*! 14,* 15*; April 9, 10, 13*!; Aug. 30*; Sept. 24*; Oct. 9,* 10,* 11*; Nov. 25*; Dec. 1,* 3,* 4, 5,* 19,* 20, 27,* 29.*

1877.—Jan. 1,*! 18, 30; Feb. 3,* 12,* 20,* 26*; March 7, 20; April 3, 16, 17; May 17,* 27,* 31*; June 1,*! 2*; Aug. 9, 19,* 25,* 28; Sept. 12, 13, 14, 15; Oct. 14,* 15, 23,* 29; Nov. 6,* 7,* 9,* 11,*! 12,*! 22, 26; Dec. 11, 22.

1878.—Jan. 21*; Feb. 27, 28; March 1,* 29, 31; May 15, 16, 17,* 19, 20*; June 11; Aug. 30*; Sept. 18*; Oct. 7,* 9, 10, 22,* 24*; Nov. 8, 9, 10*; Dec. 31.*!

1879.—Jan. 7,* 8,* 14; Feb. 10*; May 15; June 21, 26*; July 1,* 8, 9, 20*; Aug. 27,* 28*; Sept. 24; Oct. 19; Dec. 3, 4,* 28,* 30.*

1880.—Jan. 1*; Feb. 6,* 7, 9,* 15,* 16, 18, 19,* 20; March 2,* 3; April 2; July 29; Aug. 7; Sept. 14*; Oct. 5, 27,* 28*; Nov. 13, 14,* 15,* 16,* 24,* 26*; Dec. 15, 22,* 23,* 29,* 30.*

1881.—Jan. 18,* 29*; Feb. 7,* 8,* 10*; March 3,* 7, 23*; April 2,* 3, 4; May 16,* 17,* 18,* 19; June 22*; July 5, 31*; Aug. 8, 10, 17, 25*; Oct. 14,* 22*; Nov. 16,* 21, 22,* 25, 26*!, 27*; Dec. 17,* 20*.

1882.—Jan. 2,*6,* 8*; Feb. 13, 25,* 26, 27, 28*; March 1, 22,* 26*!; April 13, 25, 29*!: May 25; July 5, 6, 24; Aug. 22,* 30; Sept. 2,* 21; Oct. 21, 24*!, 27,* 28*; Nov. 2,* 3, 5; Dec. 2, 12.

1883.—Jan. 24,* 25,* 27,* 28,* 29*; Feb. 1,* 2,* 9,* 10,* 12*; March 6,* 8,* 22, 29; May 12; June 26; July 11, 21; Aug. 8,* 14*; Sept. 2,* 26*; Oct. 4, 15,* 16, 19; Nov. 24, 25*; Dec. 10, 11, 14,* 16.

1884.—Jan. 22, 23, 25,* 26*; Feb. 1, 9, 10, 11*; Sept. 6, 27; Nov. 4, 21*; Dec. 6, 7,* 10, 14,* 18.

1885.—Jan. 10, 30, 31; Feb. 2,* 6, 15, 16; May 22,* 23; Sept. 8, 10, 12. 30*; Oct. 2,* 6; Nov. 26,* 28,* 29, 30; Dec. 28.

TABLE II.

DIURNAL FREQUENCY OF BOISTEROUS OR STORMY WEATHER BETWEEN JANUARY 1ST, 1846, AND DECEMBER 31st, 1885.

Date.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1	2	1	1	4	1	...	...	...	...	1	...	...	10
2	...	4	...	1	...	...	1	...	1	1	...	2	10
3	2	2	3	4	...	2	...	...	...	1	1	1	16
4	...	2	1	...	...	...	1	...	...	2	2	3	11
5	...	1	1	1	...	...	2	...	1	2	3	3	14
6	2	2	1	...	1	1	1	1	1	2	2	2	16
7	1	3	5	...	2	...	...	1	...	2	...	2	16
8	2	1	...	...	1	...	1	1	1	2	1	1	11
9	2	2	2	6	...	1	1	2	2	1	1	1	21
10	1	1	1	2	...	...	...	2	3	1	...	3	14
11	2	...	1	1	1	1	1	2	1	...	...	3	13
12	1	...	3	...	3	1	...	...	2	...	...	2	12
13	2	1	2	3	1	1	...	1	1	...	2	1	15
14	3	1	2	...	1	2	1	1	2	...	2	...	15
15	1	1	1	2	2	2	...	1	1	1	1	2	15
16	1	2	...	3	2	...	...	...	1	3	2	2	16
17	2	...	2	1	1	...	...	1	...	...	3	...	10
18	1	4	2	1	1	...	...	1	...	1	...	2	13
19	...	...	2	1	3	...	...	...	...	2	2	...	10
20	1	1	2	...	...	...	...	...	2	...	...	1	7
21	...	1	2	1	...	1	1	2	1	1	3	...	13
22	2	...	1	...	...	...	...	...	1	1	1	1	7
23	2	...	...	2	1	...	...	...	3	1	3	...	12
24	3	...	...	...	...	...	2	1	1	...	1	2	10
25	1	...	...	1	1	...	...	1	...	2	2	1	9
26	...	1	...	...	...	1	...	...	1	1	2	1	7
27	1	2	...	...	...	...	...	...	2	...	...	1	6
28	...	1	...	...	1	...	...	1	2	1	1	1	8
29	...	1	3	...	1	...	1	...	...	1	2	2	11
30	2	...	1	...	...	...	...	1	...	1	1	...	6
31	2	...	2	...	...	...	...	...	...	...	...	...	4
Totals	39	35	41	34	24	13	13	20	30	31	38	40	358

TABLE III.

Diurnal Frequency of Gales, including Hurricanes, between January 1st, 1846, and December 31st, 1885.

Date.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1	5	2	2	...	...	1	1	...	...	...	3	1	15
2	3	2	2	3	...	2	...	...	2	1	2	1	18
3	2	2	1	...	...	...	...	1	...	2	1	2	11
4	2	...	...	1	1	...	...	...	...	...	1	2	7
5	2	2	...	...	...	...	...	...	...	1	1	3	9
6	1	3	2	...	...	...	...	...	...	2	2	4	14
7	4	2	1	...	...	...	...	1	...	2	2	2	14
8	4	3	2	1	...	...	...	2	...	...	...	2	14
9	1	2	1	...	...	...	...	1	1	2	1	...	9
10	1	4	...	...	...	1	...	1	...	4	2	...	13
11	2	2	2	...	...	1	1	1	1	2	1	2	15
12	1	4	1	...	...	...	...	...	1	2	1	...	10
13	1	2	...	1	...	1	1	...	1	1	...	...	8
14	1	...	1	1	...	...	...	1	1	2	2	2	11
15	3	1	1	1	...	1	...	...	...	2	1	3	13
16	1	...	1	...	1	...	...	...	...	...	2	2	7
17	2	...	...	...	4	...	...	...	1	2	...	2	11
18	4	...	1	...	2	...	1	...	2	...	...	1	11
19	1	1	...	1	...	...	...	1	1	1	...	1	7
20	2	1	...	...	1	...	1	...	...	...	1	2	8
21	1	1	1	1	...	...	...	...	...	2	1	3	10
22	1	...	2	...	1	1	...	2	...	3	4	3	17
23	3	...	2	1	...	...	...	...	...	4	...	1	11
24	5	1	...	...	...	...	...	1	2	4	3	...	16
25	2	3	1	...	...	...	1	2	...	...	2	1	12
26	1	2	1	...	...	1	...	...	2	4	4	2	17
27	1	2	1	...	1	...	...	1	2	3	1	2	14
28	2	3	2	...	1	...	...	2	...	2	1	3	16
29	2	...	1	1	...	...	...	1	1	4	2	3	15
30	...	...	...	...	...	...	...	2	2	...	...	5	9
31	2	...	1	...	1	...	1	1	...	1	...	2	9
Totals	63	45	30	12	13	9	7	21	20	53	41	57	371

TABLE IV.

A Summary of Monthly and Yearly Totals.

Month.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Totals.
Stormy Days	39	35	41	34	24	13	13	20	30	31	38	40	358
Gales	54	41	27	9	12	7	6	20	19	50	35	47	327
Gales with Hurricanes	9	4	3	3	1	2	1	1	1	3	6	10	44
Total Disturbances	102	80	71	46	37	22	20	41	50	84	79	97	729

TABLE V.

SHOWING THE YEARLY NUMBER OF STORMY DAYS, GALES, AND HURRICANES RESPECTIVELY, AND THEIR AVERAGE FREQUENCY.

Year.	Stormy Days.	Gales.	Hurricanes.	Total.	Year.	Stormy Days.	Gales.	Hurricanes.	Total.
1846	3	10	...	13	1866	17	8	1	26
1847	7	4	1	12	1867	9	4	2	15
1848	6	11	...	17	1868	11	11	2	24
1849	1	7	1	9	1869	...	11	2	13
1850	6	5	2	13	1870	11	5	1	17
1851	9	2	1	12	1871	8	6	...	14
1852	10	5	2	17	1872	14	19	3	36
1853	4	2	1	7	1873	10	15	...	25
1854	7	4	...	11	1874	8	16	1	25
1855	8	2	2	12	1875	5	13	...	18
1856	12	1	1	14	1876	7	15	2	24
1857	9	...	...	9	1877	19	15	4	38
1858	6	2	1	9	1878	12	10	1	23
1859	8	4	2	14	1879	8	11	...	19
1860	11	10	1	22	1880	11	18	...	29
1861	7	3	...	10	1881	10	21	1	32
1862	9	8	...	17	1882	17	11	3	31
1863	6	5	3	14	1883	13	19	...	32
1864	10	1	...	11	1884	11	5	1	17
1865	4	2	2	8	1885	14	6	...	20
					Annual Mean	8·95	8·17	1·1	18·22

TABLE VI.

SEMI-MONTHLY FREQUENCY OF GALES AND HURRICANES, 1846–1885.

Half-Months.	No. of Gales and Hurricanes from Table III.	The same values smoothed, *i.e.* $B=\frac{a+2b+c}{4}$	Half-Months.	No. of Gales and Hurricanes from Table III.	The same values smoothed, *i.e.* $B=\frac{a+2b+c}{4}$
Jan. 1–15..	33	32·25	July 1–15..	3	3·
16–31..	30	31·	16–31..	4	4·75
Feb. 1–15..	31	26·5	Aug. 1–15..	8	8·25
16–29..	14	18·75	16–31..	13	10·25
Mar. 1–15..	16	15·	Sept. 1–15..	7	10·
16–31..	14	13·	16–30..	13	14·
April 1–15..	8	8·5	Oct. 1–15..	23	22·25
16–30..	4	4·25	16–31..	30	25·75
May 1–15..	1	4·5	Nov. 1–15..	20	22·75
16–31..	12	8·	16–30..	21	21·5
June 1–15..	7	7·	Dec. 1–15..	24	25·5
16–30..	2	3·5	16–31..	33	30·75

PROFESSOR LANGLEY'S RESEARCHES ON SOLAR HEAT.

A CRITICISM OF CERTAIN POINTS,

By Prof. S. A. HILL, M.A., F.R.Met.Soc., Meteorological Reporter to the Government of the North-west Provinces, India.

[Read December 15th, 1886.]

To anyone who takes an interest in actinometric work, as I have done for several years, the volume recently published by the United States Signal Service,[1] embodying the results of Prof. Langley's expedition to Mount Whitney and his researches on solar heat and on actinometric instruments made at Allegheny Observatory before and subsequent to the expedition, comes as a welcome source of information on the subject and a most striking testimony to the scientific insight and experimental ability of the present generation of American physicists.

Some time about the year 1880 Prof. Langley appears to have been much impressed by the error, indulged in by nearly all observers, of applying Bouguer's formula to the reduction of actinometric observations. This formula, which assumes that equal quantities of air (of similar composition) will absorb similar proportions of the incident heat, has been used, as is well known, by Pouillet, Herschel, and other observers, under the form $R = Ap^{\varepsilon}$, where R is the observed radiation, A the "solar constant" or intensity of radiation at the limit of the atmosphere, p the coefficient of transmission through unit thickness (the unit adopted being the vertical thickness of the atmosphere over the place of observation), and ε the number of such units in the more or less inclined path of the rays.

Now Melloni and others having shown that the absorption of the heterogeneous radiation from a lamp by glass plates and other media does not follow this law, being always greater in the first than in the succeeding laminæ, and Jamin and Masson having expressly restricted the law to rays of one definite refrangibility, the application of the formula to actinometric reductions without further inquiry is obviously irrational. Prof. Langley therefore set himself to construct an instrument which would enable him to deal separately with homogeneous rays, to each of which the formula might rationally be applied. This instrument, which he calls the "bolometer," is essentially a very narrow strip of metal which can be slowly moved throughout the extent of the spectrum. It is traversed by a current from a constant battery, and as its electrical resistance varies with the heat which falls upon it, these variations are shown by the deflections of a very sensitive galvanometer. The instrument may be placed either in the normal spectrum given by a diffraction grating, or for practical observation in the dispersion spectrum of a flint-glass prism, the readings given in the latter case, which are affected by the selective absorption of the prism, being reduced to the corresponding values in the catoptric apparatus by suitable corrections.

This instrument, which in theory is supposed to be much superior to an ordinary actinometer, is, however, still affected by the same error; for since, however narrow we make the strip of metal, we can never reduce it to a mere line, and since absorption bands or lines have, in theory at least, perfectly definite positions and breadths, the radiation which falls on the bolometer strip in any position may, with regard to its absorption by the air, be almost as far from homogeneity as the total radiation received in an actinometer. One would expect, at any rate, that if the bolometer be a great improvement on the earlier instruments, it should at least give more consistent results; but this is far from being the case. For example, in the winter and spring of 1880-81, elaborate sets of observations were made on the radiation of different wave lengths, the results of which, after applying all the numerous and carefully determined corrections above referred to, were the following—E standing for the intensity of each ray at the outside of the atmosphere, and the scale of course being an arbitrary one.

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[1] *Professional Papers of the Signal Service.* No. XV.

RESULTS AT ALLEGHENY.

	Values of E.		
λ	Winter.	Spring.	Mean.
·375 μ[1]	1065	353	636
·400 „	1774	683	1127
·450 „	2175	1031	1515
·500 „	2335	1203	1694
·600 „	1659	1083	1344
·700 „	1000	849	922
·800 „	555	519	538
·900 „	329	316	323
1·000 „	261	309	287

These results are so extremely discordant, some of them differing by fully 200 per cent., that one or other of three conclusions is forced upon us by them: either the solar radiation varies enormously from time to time both in quantity and quality, or the bolometer is altogether untrustworthy, or the atmosphere of Pittsburgh and Allegheny is quite unsuited to such work. The first conclusion is incredible, and the second at least doubtful, but to anyone who has ever been in Pittsburgh, the smokiest town in the world of its size, there can be no doubt about the third.

A public spirited citizen of Pittsburgh having placed at Prof. Langley's disposal the means of pursuing his investigations in a better climate, and the advice and co-operation of the Signal Service Authorities having been secured, it was resolved to proceed to Mount Whitney in Southern California, a region almost free from cloud and haze during the summer months, and to establish there for a short time an observing station. The expedition arrived in July 1881, and two stations were selected where simultaneous observations could be carried on, one at Lone Pine, in a valley 3,760 feet above the sea, and the other at a camp near the top of the mountain at an elevation of 11,600 ft. The equipment consisted of the spectrobolometer, Pouillet's pyrheliometer, and Violle's globe actinometer, besides ordinary meteorological and astronomical instruments.

It is unnecessary to refer to the pyrheliometer observations, those made with the instrument as originally constructed by Pouillet being quite erroneous, owing to the imperfect conductivity of the water and its clinging to the walls of the enclosing chamber, while even when mercury was substituted for water, as had been suggested by Tyndall, the results were lower and less trustworthy than those given by the globe actinometer. This instrument consists of two concentric spherical envelopes, the space between them being filled with water, while at opposite poles there are small cylindrical openings into the inner spherical space, the axis of these being directed towards the sun, while the upper opening may be opened or closed at will by a shutter. A thermometer in the outer space shows the temperature of the enclosure, which is maintained nearly constant by the flow of a current of water through it. Another thermometer with a blackened bulb at the centre of the sphere is the real actinometer. To determine the quantity of heat received per minute by a square centimetre of surface exposed perpendicularly to the sun's rays, we only require to know the sectional area of this thermometer bulb, its thermal capacity, and the initial rate of heating per minute.

The thermal capacity of the bulb may be calculated from its external diameter and the quantity of mercury in it, these data enabling us to compute the thickness of the glass. Violle thought he had determined these data for the thermometer used in his Mont Blanc observations, by taking a thermometer "in every way resembling" the one used and breaking it off close to the bulb; but Langley shows that the thermal capacity arrived at by Violle could, with the dimensions he states, be given by no combination of glass and mercury, and that, therefore, Violle's result for the "solar constant" must necessarily be wrong.

After attempting to find the quantity of mercury in the thermometers used at Mount Whitney by balancing them in air and water against a counterpoise, Langley finally adopted the method of determining the thermal capacity directly by a small calorimeter, a method which gives exact results. The mean diameter of the bulb, and hence its sectional area, are easily determined by callipers, but the initial rate of heating is more difficult to get at. Violle's *modus operandi* was to close the shutter until the two thermometers read alike, and then to open it, noting the thermometer readings every five minutes. At the end of fifteen minutes the shutter was closed, and the thermometers were again read at intervals of five minutes. The third reading in this second stage was always identical, or nearly so, with the temperature of the enclosure, the thermometer bulb being very small. Langley worked in the same way, but his thermometers being larger he found that fifteen minutes did not suffice for the attainment of equilibrium. Moreover, he found that the curves of rising and falling temperature were not logarithmic, as Violle had assumed, and hence the true initial rate could not be deduced from observations made at five-minute intervals. It became necessary, therefore, to make special observations at very short intervals (of thirty seconds), and to find the ratio between the initial rate thus determined and that deduced from readings at five-minute intervals, this ratio being afterwards applied as a correcting factor to all the computed results.

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[1] μ Stands for a *micron*, the millionth part of a metre.

The following is a complete list of the corrections applied to the results of observations made and reduced by Violle's method:—

A. Correction for initial rates, as above described.
B. Correction for imperfect conductivity of mercury in the thermometer bulb.
C. „ „ imperfect absorption by thermometer bulb.
D. „ „ unfinished exposure (the time, fifteen min., being too short for the attainment of equilibrium).
E. „ „ variation of atmospheric pressure affecting the rate of cooling.
F. „ „ sky radiation received by the thermometer along with that from the sun.

The first four corrections are positive in sign and the last two negative. They were all neglected by Violle.

The application of all these corrections except the second seems justifiable and necessary. The second is, however, it seems to me, founded on a misapprehension, and if it have any meaning at all it should be included in the third. Owing to the imperfect conductivity of the glass a certain minute fraction of the radiation may not reach the mercury during the time of exposure and the initial rate of heating will be diminished, but the quantity of heat actually imparted to the mercury will cause exactly the same rise of the thermometric column whether it be uniformly disseminated throughout its volume or confined to a portion of it.

For if we take the volume of the mercury to be unity, and c its thermal capacity per unit of volume, a quantity of heat added $= h$ will produce a rise of temperature $\frac{h}{c}$, and if the coefficient of apparent expansion be a, the total apparent dilatation, which is what we measure, will be

$$\delta = \frac{h}{c} \cdot a$$

Now if the same quantity of heat be confined to a portion of the mercury p, the rise of temperature in this will be $\frac{h}{pc}$, and the expansion of this portion for each degree will be pa, therefore the total dilatation

$$\delta_1 = \frac{h}{pc} \cdot pa$$

It follows that if c be constant, as it is between the limits of temperature in any practical observation, δ_1 and δ are equal, or the rise of the thermometric column will be the same in both cases.

The amount of this correction B was found to vary from 8·3 to 6 per cent., according to the incidence of the rays, being greatest when the rays come from the zenith and equal to zero when they come (by reflection) from the nadir, the mercury then being warmed throughout by convection currents. The fact that so large a correction was found for a purely imaginary error casts a doubt on the accuracy of some of the others.

Actinometric observations were made regularly in the morning, about noon and in the afternoon, from August 18th to September 6th, the results being combined and the constant of solar radiation outside the atmosphere being computed by a modification of Bouguer's formula. To the latter result, however, the author attaches little value for the reasons above given ; but he uses the value of the observed radiation to compute by the method of proportionate areas the value in calories of the solar constant from the graphical representation of his bolometer observations. These actinometric observations prove that the absorption at mountain stations is greater for equal air masses in the afternoon than in the forenoon, the difference being probably due to the upward diffusion or convection of water vapour. This fact was established as long ago as 1869 by Mr. Hennessey's observations at Mussoorie, and in 1881[1] I pointed out the cause, using for the purpose of establishing my conclusion that water vapour is the chief absorbent three long series of observations made simultaneously at Mussoorie and Dehra by Mr. Hennessey and Mr. Cole, during the months of November 1869 and November 1879. The discovery of the diurnal variation of atmospheric absorption seems to strike Prof. Langley as new, and in his historical introduction I can find no reference to Mr. Hennessey's work.

Out of the mass of actinometric observations made at the two stations, those of August 23rd and 25th have been selected by Prof. Langley for complete discussion, the days having been exceptionally clear and the observations exactly simultaneous at the two stations. The discussion is in one respect too complete, for not only are the solar constant and the transmission coefficient computed from high and low sun observations at each place on each day, but the observations of the two days are combined, and finally the observations of the two stations are combined. This latter procedure the observer perceives to be illegitimate, for it assumes that the atmosphere is of the same composition below and above Mountain Camp, which is obviously not the case, the lower layers containing a much larger proportion of water vapour, and also of dust, than the upper. To combine the observations of different days is illegitimate in a less degree for a similar reason, and this Mr. Langley notices when he comes to the bolometer observations, but not in connection with the actinometer.

The results briefly tabulated are these :—

Station.	*Solar Constant.*	*Transmission Coefft.*
Lone Pine	2·019	0·8620
Mountain Camp	2·131	0·8623
Both combined	2·705	0·6922

If we reject the combined observations for different stations and different days we get the following mean values :—

Station.	*Solar Constant.*	*Transmission Coefft.*
Lone Pine	2·044	0·8589
Mountain Camp	2·119	0·8721

The solar constant is given in "small" calories per square centimetre per minute, and the transmission coefficient is calculated for an atmosphere of 760 millimetres pressure and of the same composition as that above the station.

Prof. Langley concludes, from these and other observations, that the deduced value of the solar constant increases as we ascend, and that for this as well as other reasons its true value is probably considerably higher than any hitherto assigned to it. But when we confine the application of Bouguer's formula to observations of one day only, as Pouillet did when he first applied it to solar heat, or better still if we could restrict it to observations so near each other in time as to insure practical constancy of the atmospheric conditions, but so distant as to give lengths of path differing considerably—if we made the observations say hourly, and computed each pair separately—we should, I think, find no evidence of any such increase. Already, by confining the application of the formula to the observations of a single day, it is seen that the excess of the Mountain Camp result above that for Lone Pine is reduced from 0·112 to 0·075 calorie ; and in two out of the three long series of observations at Mussoorie and Dehra which I have discussed the lower station indicates the larger value for the solar constant.

From the above results, combined with barometric and hygrometric observations made at the same time, Prof. Langley proceeds to compute the relative absorbing powers of dry air and water vapour for the whole radiation, similar computations being made for radiation of each standard wave length, the latter being derived from the bolometer observations. His notation is cumbrous, and the calculation for the whole radiation will probably be more intelligible if carried out in the same manner as my computation of the results of the Mussoorie and Dehra observations.[1] We have for

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[1] *Proceedings of the Royal Society.* No. 217, 1881.

	Lone Pine.	Mountain Camp.
Transmission coefficient for standard atmosphere ..	0·8589	0·8721
" " " actual atmosphere ..	0·8763	0·9139
Barometric pressure	25·98 in.	19·68 in.
Mean vapour tension	0·236 in.	0·071 in.

Hence putting $p = x\beta, y^{f}$, where x and y are the transmission coefficients of air and vapour at one inch pressure respectively and with the observed vertical distribution, and β and f the barometric pressure and vapour tension respectively, we have

$$\log.\ 0{\cdot}8763 = 25{\cdot}98 \log.\ x + 0{\cdot}236 \log.\ y,$$
$$\log.\ 0{\cdot}9139 = 19{\cdot}68 \log.\ x + 0{\cdot}071 \log.\ y.$$

These give $x = 0{\cdot}99577$ and $y = 0{\cdot}91111$, results which differ considerably from mine computed from the Mussoorie and Dehra observations, viz. $x = 0{\cdot}99855$ and $y = 0{\cdot}72783$.

The hygrometer readings do not appear to have been made with the same care and attention to detail as the rest of the observations on this important expedition. One of the wet-bulb thermometers was covered with thin muslin and the other with thick lampwick, and though it is doubtful at which station the wick was employed there cannot be any doubt that the two sets of observations are not strictly comparable. Moreover the relative humidity was so low that the observed temperatures lay in many instances beyond the limits of Guyot's Tables, and comparative observations with Regnault's hygrometer gave widely discordant results. When it is added that the observer at Mountain Camp read his thermometers only to the nearest degree, we may conclude that no deduction like that just made, when founded on such data, is entitled to confidence.

The bolometer observations are discussed much more fully than those of the actinometer. Observations were made of the radiation received under each of the standard wave lengths given in the first table above, and repeated with both high and low sun at each of the stations. The tables obtained were afterwards extended from $\lambda = \mu$ to $\lambda = 3\mu$ nearly, by means of observations made at Allegheny, a proceeding which is not very trustworthy, but cannot introduce any considerable error, as the energy of these long waves is relatively small (according to Langley), and their transmission coefficients, except in certain bands of special selective absorption, nearly equal to unity.

The observations of the two stations were then reduced by various methods of combination, Bouguer's formula being applied to the radiation of each standard wave length. The combination of high and low sun observations at one station is rejected on the grounds that we cannot be sure of the constancy of the atmospheric conditions over the place of observation, nor of their similarity in the distant regions traversed by very oblique rays. The combination of simultaneous observations at the upper and lower station (the method adopted by Forbes in reducing his well-known Faulhorn observations) is equally rejected on account of the certainly dissimilar atmospheric conditions above and below the mountain station. Finally, the method of combining the observations of Mountain Camp and Lone Pine and assuming one coefficient of transmission for the upper and another for the lower layers of the atmosphere is adopted, and seems to be the best under the circumstances. It gives resulting values for the energy outside the atmosphere which are intermediate between those arrived at by the other two methods.

The tabulated results of the relative energy under each wave length, as given by observations at Allegheny, Lone Pine and Mountain Camp, and by computation for the upper limit of the atmosphere, are then plotted as the ordinates of curves whose abscissæ are the wave lengths, and the curves are then drawn. When the value in calories of the radiation received per square centimetre of surface from a vertical sun at Mountain Camp is multiplied by the ratio of the areas of the last two curves, it is assumed that we have arrived at the nearest approximation to the true value of the solar constant yet attained. This value is about 3 calories per minute.

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[1] *Proceedings of the Royal Society.* No. 219, 1882.

Regarding the distribution of energy in the spectrum and the relative absorptive powers of the atmosphere for different wave lengths, very startling results are announced. The greatest energy in the unabsorbed solar rays is not in the red or infra-red, as is taught in text-books of Physics (this, however, being due to the mistake of constructing the diagram of energy on a prismatic spectrum, in which the red rays are crowded together and the blue widely dispersed), but in the yellow and green, the maximum lying about $\lambda = 0{\cdot}5\ \mu$; and leaving out of consideration certain "telluric lines" or bands of specially active absorption, the transmission coefficient increases regularly from the violet to the extreme ultra-red, about $\lambda = 2{\cdot}8\ \mu$, where it seems suddenly to cease. On these two results Prof. Langley based some years ago the startling announcement that if we could see the sun without the intervention of the atmosphere, it would appear to our eyes decidedly blue, a statement which even those who have not worked with the bolometer can perceive to possess some degree of truth, since the blue colour of the sky is due to the scattering of the rays of short wave length by atmospheric particles.

These results, and the further conclusion that the absorptive power of water vapour is greatest, broadly speaking, for the shortest waves, are so directly opposed to all that has hitherto been known of the behaviour of the atmospheric constituents with regard to radiation, that they will require rigid verification in the laboratory before they can be accepted as true.

There are several general considerations on which Prof. Langley's results, founded as they are upon the use of an instrument which, so far as I know, has only been employed by himself and his assistants, are open to question. In the first place, he makes the undiminished solar intensity about 3 calories per centimetre per minute, whereas only about half this quantity penetrates to sea-level even with a vertical sun. From this it may be inferred that the atmosphere is quite as much heated by direct absorption of the solar rays as by contact with the ground surface. Now the observed rate of decrement of temperature in the atmosphere points to a different conclusion. This rate is about 1° F. in 300 ft. on mountain sides, but in the free atmosphere over an open country Glaisher found it to amount to about 43° F. in 10,000 ft. on clear days, or 1° in 233 ft. This average rate is almost as rapid as that which may be deduced by thermodynamical principles from the assumption that all the heat is imparted at the bottom where the air is in contact with the ground; and near sea-level the rate is even more rapid. I think the inference is a legitimate one, that the heat imparted to the atmosphere by direct absorption of the solar rays is, comparatively speaking, insignificant.

Again, Prof. Langley concurs in the general opinion that the actual temperature of the earth's surface is maintained by the selective absorption of the atmosphere, that were it not for the atmosphere the temperature would fall as low as that of the moon, which he has shown to be, even in full sunshine, but little above the absolute zero. But on his own showing the air is comparatively opaque to luminous rays, especially those near the blue end of the spectrum, and almost perfectly diathermanous to the ultra-red rays as far as $\lambda = 2{\cdot}8\ \mu$, or thereabouts. It follows, therefore, that the sun's heat finds a difficulty in reaching the earth, but the earth's radiation, if it be of the kind generally supposed, can escape into space with the utmost facility. The earth should, therefore, cool off with great rapidity. To avoid this absurd conclusion, Prof. Langley is forced to assume (p. 213) that "the heat-storing action, from checked re-radiation, to which the surface temperature of this planet is due, apparently goes on beyond these limits where no spectral measurements have yet been made. No such wave lengths as those radiated from the soil, we believe, have ever entered our atmosphere from the sun, though we admit their existence in the solar spectrum before absorption." Whatever the second clause of this last sentence may mean, it is clear from the context that he thinks the radiation from the bodies of low temperature like the earth's surface is of an altogether different order from the dark rays of the solar spectrum, and that the wave length of such radiation is probably much greater than $3\ \mu$, that is to say, these dark rays would occupy a portion of the spectrum the possible existence of which has been denied by competent mathematicians and physicists. A conclusion so much at variance with established principles as this should obviously be based on direct experiments in the laboratory, not deduced by a very long and roundabout process from actinometric observations.

Finally with respect to Pouillet's application of Bouguer's formula to the totality of the solar rays received in the pyrheliometer, I do not think the procedure so erroneous as Langley proclaims it to be. I have read Pouillet's memoir on the subject, and find that he does not adopt the formula as giving a rational account of the process of atmospheric absorption, but merely as representing closely the results of observation. With Pouillet's data, when the logarithms of the observations of any single day are taken as ordinates, and the corresponding atmospheric thicknesses as abscissæ, the resulting curve does not differ sensibly from a straight line. Fröhlich[1] arrives at the same conclusion with respect to the formula from his observations with the thermo-pile. My own computations from Mr. Hennessey's observations lead to the same conclusion, with the proviso that (in warm climates at least) we should combine observations made at equal hour angles before and after noon, in order to eliminate the effect of the diurnal variation of vapour tension. There is, therefore, good ground for supposing that Pouillet's formula, with proper restrictions, does give true, or at any rate comparable, results for the solar constant and the transmission coefficient of the atmosphere.

The reason why this empirical formula should yield results which are probably more consistent than those obtained by Langley's elaborate process, is doubtless to be found in the fact that as the depth of atmosphere traversed by any ray increases, its absorptive power increases, owing to the larger proportion of water vapour and dust particles in it. If the absorptive powers of all atmospheric layers of equal mass were equal while the absorption is selective we should find the transmissibility of the remaining radiation continually increasing as it approaches the earth, but we find exactly the opposite. It is probable, therefore, that although by lumping together all the different varieties of radiation we should arrive by the formula at much too low a value for the undiminished solar heat, as Langley has conclusively shown, if all equal masses of air had equal absorbing powers, the actual atmosphere is so constituted as to allow the simple formula to give results which are very nearly true. That this is so is most fortunate, for what is wanted in meteorology is not so much a knowledge of the exact value of the solar "constant," as of the variations of this quantity, which there are many reasons for believing to be by no means constant; and the method of Langley is far too laborious and troublesome to be ever available for a continuous series of observations extending over a number of years.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

NOVEMBER 17TH, 1886.

Ordinary Meeting.

WILLIAM ELLIS, F.R.A.S., President, in the Chair.

BENJAMIN ALFRED DOBSON, J.P., Doffcockers, near Bolton;
THOMAS GORDON, 7 Scotch Street, Whitehaven;
HENRY MANTLE, Northgate, Lincoln;
REV. JOHN WATSON, Wesley Villa, Sedbergh; and
FREDERICK WRIGHT, 246 Castlereagh Street, Sydney, New South Wales,
were balloted for and duly elected Fellows of the Society.

The following Papers were read, viz.:—

"THE GALE OF OCTOBER 15TH-16TH, 1886, OVER THE BRITISH ISLANDS." By CHARLES HARDING, F.R.Met.Soc. (p. 1.)

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[1] *Annalen der Chem. u. Ph.*, No. 1, 1884.

"THE CLIMATE OF CARLISLE." By THOMAS G. BENN, F.R.Met.Soc. (p. 14.)

"RESULTS OF HOURLY READINGS DERIVED FROM A REDIER BAROGRAPH AT GELDESTON, NORFOLK, DURING THE FOUR YEARS ENDING FEBRUARY 1886." By E. T. DOWSON, F.R.Met.Soc. (p. 21.)

"RESULTS OF OBSERVATIONS TAKEN AT DELANASAU, BUA, FIJI, 1881-1885." By R. L. HOLMES, F.R.MET.SOC. (p. 30.)

DECEMBER 15TH, 1886.

Ordinary Meeting.

WILLIAM ELLIS, F.R.A.S., President, in the Chair.

GEORGE RICHARD FARNCOMBE, B.A., Greenhill, Handsworth, Birmingham ;
CHARLES EDWARD BOLTON HEWITT, B.A., Marlborough College ; and
CAPT. SAMUEL TROTT, s.s. "Minia," Halifax, Nova Scotia,
were balloted for and duly elected Fellows of the Society.

Mr. F. C. BAYARD and Mr. R. STRACHAN were appointed Auditors of the Society's Accounts.

The following Papers were read, viz. :—

"ON THE PROCEEDINGS OF THE INTERNATIONAL CONGRESS OF HYDROLOGY AND CLIMATOLOGY AT BIARRITZ." By G. J. SYMONS, F.R.S., F.R.Met.Soc. (p. 46.)

"REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1886." By the REV. T. A. PRESTON, M.A., F.R.Met.Soc. (p. 60.)

"A CRITICISM OF CERTAIN POINTS OF PROF. LANGLEY'S RESEARCHES ON SOLAR HEAT." By PROF. S. A. HILL, B.Sc., F.R.Met.Soc. (p. 85.)

"ACCOUNT OF THE HURRICANE OF MARCH 3RD-4TH, 1886, OVER THE FIJI ISLANDS." By R. L. HOLMES, F.R.Met.Soc. (p. 37.)

"RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE MILITARY CEMETERY, SCUTARI, CONSTANTINOPLE, 1866-85." By W. H. LYNE (p. 75.)

CORRESPONDENCE AND NOTES.

CONNECTION BETWEEN AGGREGATE TEMPERATURE AND AGRICULTURAL PRODUCTION.

PROFESSOR J. H. Gilbert, F.R.S., at a recent meeting of the Société Helvétique des Sciences Naturelles, held at Geneva, read a paper on the connection between Aggregate Temperature and Agricultural Production, which is printed in *Archives des Sciences Physiques et Naturelles*, troisième période, Tome XVI. p. 421. The following is a brief recapitulation of the principal points in the communication.

After mentioning previous investigators of the subject, as A. de Candolle and Boussingault, Dr. Gilbert gave an account of the researches carried on for twenty-seven years by Sir J. B. Lawes and himself, at Rothamsted, taking as the data for temperature the monthly mean temperatures at Greenwich for the 27 years, and the daily means for 6 years. He then described the mode of calculation of accumulated temperature adopted in the *Weekly Weather Report*, which gives the number of 'day degrees' above 42° Fahr. per week.

A measure of the accordance between the results of the two methods is given by the following figures for a definite period in two successive years :—

	By ordinary Daily Means.	By Meteorological Office "Day Degrees.'
1881	1664°	1623°
1882	1573°	1525°

Dr. Gilbert gives the following table, of which the first two portions refer to Greenwich data, using monthly means for the twenty-seven years, and daily means for the six years. The third portion refers to the eight years given in the Appendix to the *Weekly Weather Report* for 1884, and in the subsequent weekly reports; and the results are the means of the figures for the East of England and Midland Counties. In each case the extreme value in any year is given, and the mean of the period.

AGGREGATE EXCESS OF DAILY MEAN TEMPERATURE ABOVE 42° FROM FIXED DATES, OR FROM COMMENCEMENT OF ACTIVE ABOVE-GROUND GROWTH, TO DATE OF HARVEST AT ROTHAMSTED.

Years.		From Jan. 1.	From Feb. 1.	From March 1.	From April 1.	From date of excess nearly every week.	From date of weekly excess after a break.
Greenwich Data—		°	°	°	°	°	°
27 years, 1852–78.	Max.	2183	2183	2183	2183	..	..
	Min.	1864	1845	1845	1808	..	..
	Mean	2023	2018	2004	1981	..	..
Greenwich Data							
6 years, 1871–76.	Max.	2285	2259	2181	2123	..	..
	Min.	2064	2015	1985	1875	..	..
	Mean	2189	2143	2098	2008	..	..
Meteorological Office—							
1878		1999	1950	1864	1768	1999	1950
1879		1990	1990	1962	1881	1990	1961
1880		1995	1976	1899	1744	1976	1976
1881		1816	1814	1804	1699	1814	1804
1882		2018	1968	1891	1703	2026	1966
1883		1790	1743	1665	1628	1772	1645
1884		1847	1757	1687	1561	1847	1686
1885		1774	1752	1674	1601	1774	1696
Max.		2018	1990	1962	1881	2026	1976
Min.		1774	1743	1665	1561	1772	1645
Mean		1904	1869	1806	1698	1900	1836

The Table shows—1. That there is very little difference whether the period begins with January 1st or April 1st on the twenty-seven year period, using only monthly means. There is more with the Greenwich daily means, and most with the *Weekly Weather Report* figures.

The results show that for wheat, from the Meteorological Office figures, the total number of aggregate degrees of heat is, for the last two columns, 1900° and 1836° respectively.

Boussingault's results gave for Winter wheat 2369°, and for Spring wheat 2750°; but his figures relate to widely different countries and climates; and he adopted an average mean temperature for the whole period of growth.

Hervé-Mangon's results for North-west France give 1854°, which is much nearer the Rothamsted figures.

Risler's figures for Nyon in Switzerland, correspond to 2192°.

Boussingault and Hervé-Mangon have both investigated the question for barley, and their results give respectively, for Spring sown barley 2005° and 1989°, nearly approaching the Rothamsted values for wheat.

Boussingault's results for maize correspond to 3515°.

The paper concludes with some remarks by Dr. Gilbert on the degree to which his figures really represent the conditions which influence the growth of the plant. He remarks also on the fact that the period of maximum duration of sunshine precedes that of maximum temperature, and quotes some results with growing wheat, showing that the plant assimilates carbon more rapidly at the latter than at the former epoch.

AN IMPROVED PYRHELIOMETER. BY THE REV. FENWICK W. STOW, M.A., F.R.MET.SOC.

POUILLET'S pyrheliometer, as usually made, appears to be open to serious objection. When turned away from the sun it cools very slowly because of the solar rays which fall on the side of the instrument. Moreover the change shown by the thermometer is greatly affected by the wind. I therefore had a silvered tube made in 1874, in which the instrument was placed, and thus shielded from wind, and from all solar rays, except when the tube was turned directly towards the sun. In use, the rise which took place in a given time while the sun's rays fell vertically upon the base was carefully noted, and then the fall which took place in the same interval of time while the base was directed to a clear portion of the sky away from the sun. The sum of the two was taken as the measure of radiation, the latter being assumed to represent the additional rise of temperature which would have been been observed if the radiation from the surface exposed to the sun could have been arrested.

This instrument is the first which was made on this plan by Mr. Casella, who was most obliging and helpful to an extent which I cannot adequately acknowledge. The other instruments are smaller and more portable, and were made in pairs exactly alike, one pair to contain water and the other mercury. The mercury in the latter weighed 1450 grains, the water in the former 236 grains, at 90°. By the co-operation of Colonel Ward a number of observations were made at Rossinière in Switzerland. Two minutes was adopted for the exposure of those containing mercury; five minutes in the case of those containing water, an interval of 30 seconds being allowed in which to turn and adjust the instruments. Each pair was first of all most carefully compared in actual use side by side, and then one was observed on a mountain-top and the other in the valley. Rossinière being surrounded by mountains 3,000 to 5,000 feet above the valley, which is at an elevation of 3,000 feet above sea-level, there was no difficulty in signalling to the observer below to begin or cease.

It may be of interest to append results obtained, together with those of solar radiation thermometers and dry and wet-bulbs. It will be seen that solar radiation as shown by these pyrheliometers was decidedly more powerful at the upper station. The instances of the contrary were generally instances of high dew-point at the upper station, and of a difference of elevation not exceeding 1,400 ft.

The first three sets of observations were taken by me, the others all by Colonel Ward, who expended much time and pains upon the work.

The solar thermometers never showed diminution of radiation with elevation to the extent of half a degree. Their results showed a general agreement with those of the pyrheliometers, but were subject to less fluctuation.

With regard to the value of the improved pyrheliometer, I think it a good actinometer. It is desirable, however, to make prolonged observations, and to reject the first few on each occasion, till the rise in the sun nearly equals the fall in the shade. Great quickness is necessary in reading the thermometer at the exact moment. Thus used, they are of value for comparing radiation at different places or on different days, but I doubt whether it is possible by such means to arrive at any trustworthy determination of the absolute heating power of the sun.

OBSERVATIONS OF SOLAR RADIATION TAKEN WITH IMPROVED PYRHELIOMETERS AT ROSSINIÈRE, SWITZERLAND, IN 1875-7, BY REV. F. W. STOW AND COLONEL WARD.

Date.	Time when Observations		Name of Mountain.	Height of Upper Station above Lower (the latter 3,000 ft. above Sea).	Pyrheliometers containing				No. of Double Observations.
					Mercury.		Water.		
					Mean Change in 2 minutes.		Mean Change in 5 minutes.		
	Began.	Ended.			Below.	Above.	Below.	Above.	
1875.									
Sept. 6	10·23	11·32	Cray	3800	6·24	7·10	..	..	12
„ 8	9·3	9·58	Corjeon	3474	6·77	7·07	..	..	11
„ 17	10·32	11·30	Rubli	4500	5·82	7·45	..	..	12
Oct. 2	11·48	0·28	Bugnion	600	5·45	6·20	..	..	8
Nov. 3	0·5	0·48	?	1000	6·28	7·07	..	..	9
1876.									
July 6	4·44	5·33	..	600	..	..	4·92	5·22	4
July 27	11·35	0·24	..	1400	..	..	7·60	7·22	4
Aug. 8	9·29	10·18	Corjeon	3474	..	..	6·30	5·75	4
Oct. 2	11·33	1·18	Cray	3000	..	..	8·02	9·06	8
?	2·29	3·32	Cray	3800	..	..	7·20	7·60	5
?	0·19	1·22	Cray	1000	..	..	8·30	7·60	5
?	2·14	3·31	Cray	1000	8·70	7·20	..	..	6
1877.									
June 8	9·10	10·55	Cray	3800	..	..	7·50	8·24	13
?	10·59	0·44	Cray	3000	..	..	8·29	12·65	8

Date.	Radiation by Solar (blackened and clear bulb) Thermometers.		Hygrometers.				Dew-Point.		Difference in Radiation by Pyrheliometer Columns, 7–6 or 9–8.	Ditto by Solar Thermometer Columns, 13–12.
			At Lower Station.		At Upper Station.		At Lower Station.	At Upper Station.		
	Below.	Above.	Dry Bulb.	Wet Bulb.	Dry Bulb.	Wet Bulb.				
1875.	°	°	°	°	°	°	°	°		
Sept. 6	..	..	65·0	58·5	..	..	..	..	+0·86	..
„ 8	..	..	69·0	60·0	48·1	46·3	53·0	44·3	+0·30	..
„ 17	..	..	..	..	..	..	..	..	+1·63	..
Oct. 2	..	..	56·5	50·4	..	..	44·7	..	+0·75	..
Nov. 3	..	..	42·5	38·0	42·5	38·0	32·8	32·8	+0·79	..
1876.										
July 6	29·8	29·9	74·0	63·0	70·8	60·7	55·0	53·0	+0·30	+0·1
July 27	35·5	38·1	75·1	63·5	66·0	59·7	55·2	54·5	—0·38	+2·6
Aug. 8	34·4	41·5	67·6	62·1	62·4	58·4	57·6	55·0	—0·55	+7·1
Oct. 2	34·5	41·8	68·3	59·0	68·0	55·0	51·7	44·7	+1·04	+7·3
?	26·1	30·9	59·5	50·5	42·0	37·0	42·5	30·9	+0·40	+4·8
?	37·2	36·8	68·6	56·7	65·5	55·5	47·3	47·3	—0·70	—0·4
?	30·2	30·1	68·2	57·2	64·0	56·5	48·5	50·3	—1·50	—0·1
1877.										
June 8	36·3	38·6	66·7	61·6	60·0	52·4	57·3	45·7	+0·74	+2·3
?	40·0	41·0	57·7	47·5	55·7	44·4	38·3	33·7	+4·36	+1·0

DEW.

Mr. J. AITKEN, in a paper "On Dew" in the *Transactions of the Royal Society of Edinburgh*, Vol. XXX. p. 111, proves by repeated experiments that dew does not fall, and is not condensed from the air but rises from the ground. He says, "We see as a result of these experiments, that in our climate at least water vapour is almost constantly rising from the ground, and this takes place from fallow land, from grass land, and from roads, even on nights on which there is heavy dew. There seems to be but little doubt that the tide of vapour almost always flows outwards from the earth, and ebbs but rarely save after it has been condensed to clouds and rain. The question as to whether any surface is in a condition to lose or gain moisture on a dewy night depends on its more or less perfect heat communication with the earth. Those surfaces, such as soil, rock, stones, &c. which are in good heat communication with the earth, tend to keep warm, and to lose moisture; while those surfaces not in good communication with the earth, such as leaves of plants, roofs of sheds, &c. tend to lose their heat and gain moisture; this is the reason why grass tends to collect true dew, while stones on the ground remain dry. Grass is a bad conductor, and forms a non-conducting layer over the ground, preventing the earth from losing its heat.

"Since vapour is constantly rising from the earth on dewy nights, it follows that any measurements of dew we may make ought not to be added to the rainfall, as the water so collected is in no sense a measure of the moisture returned to the earth at night, nor is it even a proof that any water is returned."

Mr. Aitken shows also that the dewdrops appearing on the edges of leaves of plants are not dew at all, but water forced out through the pores of the plants by root pressure. He reproduced the phenomenon repeatedly, and found that the root pressure, e.g. of cabbage, was 130 mm., so that it could force its sap up to a height of 58 feet.

He gives the following as his principal conclusions:—"1st. From the experiments made with (*a*) the inverted trays, (*b*) by weighing small areas of turf, and (*c*) by observations of the temperature on and under the grass during dewy nights, we have concluded that vapour is almost constantly rising from grass land, by night as well as by day, in our climate. 2nd. From experiments made with (*a*) inverted trays, (*b*) by weighings of small areas of soil, and (*c*) by observations made with small test condensing surfaces, on dewy nights, we have concluded that, under most conditions of our climate, vapour rises from uncultivated areas of soil during night as well as by day. It follows from these two conclusions that dew never 'falls' on the earth; and for reasons given it is only deposited on plants and other bodies not in good heat communication with the ground. 3rd. That the greater part of the dew condensed on bodies near the ground is formed of the vapour rising at the time from the earth, and very little of it from the vapour that rose during the day. 4th. That dew forms copiously on roads, but owing to the stones being good conductors of heat, the vapour is deposited on the undersides of the stones, and not on the top as on grass. 5th. Wind hinders the formation of dew by preventing accumulation of damp air near the ground. 6th. The "dewdrop" formed on grass and other plants is not dew at all, but is formed of the exuded sap of the plant. 7th. Almost all substances, such as black and white cloths, garden mould and grass, radiate equally well at night. Among the few exceptions observed are polished metals and sulphur. 8th. A covering of snow on the ground lowers the mean temperature of the air."

METEOROLOGY OF JAPAN.

THE Imperial Meteorological Observatory of Tokio, Japan, has just issued the "Report of the Meteorological Observations for the ten years 1876-1885." The Observatory was established in June 1875, but the observations were not commenced till January 1876. The late Mr. H. B. Joyner, F.R.Met.Soc., was in charge of the Observatory till July 1877, when he left. The present Director is Mr. I. Arai.

Table I. gives a monthly summary of the results.

The Tokio Observatory has also organised a Weather Service for Japan, and publishes Daily Weather Charts and issues Storm Warnings.

TABLE I.—Average Monthly and Annual Means, Tokio, Japan, 1876-1885.

Months.	Pressure at sea level.	Temperature.			Relative Humidity.	Amount of Cloud 0—10.	Rainfall.
		Mean.	Mean.				
			Max.	Min.			
	Ins.	°	°	°	%		Ins.
January	30·040	36·6	46·8	27·7	67	3·5	2·34
February	·081	38·4	47·3	30·0	70	5·3	4·01
March	·009	43·4	53·3	34·0	71	5·4	4·77
April	30·029	53·7	62·5	44·1	78	6·4	4·62
May	29·898	61·9	70·5	52·8	79	6·6	5·45
June	·848	68·8	75·6	61·6	84	7·8	7·81
July	·852	76·0	83·2	69·4	83	6·9	5·06
August	·874	77·4	85·5	70·6	82	6·1	4·01
September	29·946	71·2	78·9	64·7	83	7·3	8·84
October	30·061	60·2	68·9	52·3	81	6·5	7·67
November	30·048	49·2	59·4	40·0	76	4·8	3·76
December	29·998	40·9	51·7	31·6	71	3·7	2·12
Year	29·974	56·5	65·3	48·2	77	5·9	60·46

Table II. gives the results of pressure, temperature and rainfall from 25 stations in Japan for the year 1885.

TABLE II.—Metrological Results from Stations in Japan, 1885.

Stations.	Lat.	Long.	Height.	Pressure at sea level.	Temperature.	Rainfall.
	N.	E.				
	° ′	° ′	ft.	Ins.	°	Ins.
Nagasaki	32·44	129·52	189	30·024	59·7	99·57
Kagoshinia	31·35	130·33	11	·028	61·2	86·22
Miyasaki	31·56	131·26	26	·040	60·8	106·93
Kochi..................	33·33	133·34	20	30·004	59·5	99·89
Wakayama	34·14	135·9	48	29·997	58·6	67·40
Hiroshima	34·23	132·27	14	30·008	57·4	73·11
Osaka..................	34·41	135·30	45	·004	57·9	63·11
Kioto	35·1	135·46	162	·004	56·1	71·10
Shimonoseki.............	33·58	130·56	135	·028	57·9	73·54
Sakai	35·31	133·13	8	30·004	56·3	86·02
Kanazawa	36·33	136·40	95	29·997	54·3	129·96
Fushiki	36·47	137·3	14	29·977	55·6	84·17
Gifu	35·27	136·46	49	30·008	56·3	95·04
Hamamatsu	34·43	137·43	91	29·973	57·6	90·91
Numazu	35·6	138·51	33	·957	57·7	88·50
Tokio	35·41	139·46	69	·969	55·4	60·55
Niigata.................	37·55	139·3	32	·973	53·8	76·02
Akita	39·42	140·7	33	·953	50·5	70·43
Miyako	39·38	141·59	100	·941	48·7	57·64
Aomori	40·51	140·45	33	·930	47·5	42·99
Hakodate	41·46	140·44	10	·918	46·2	47·21
Sapporo......	43·4	141·23	60	·894	43·9	39·10
Nemuro	43·20	145·35	43	29·886	41·0	43·35
Fusan	35·6	129·3	26	30·048	54·0	57·40
Vladivostok	43·0	132·30	98	29·945	37·9	45·63

RECENT PUBLICATIONS.

American Meteorological Journal. A Monthly Review of Meteorology, Medical Climatology and Geography. Vol. III. Nos. 5-8, September-November 1886. 8vo.

The principal contents are: Loomis' "Contributions to Meteorology." The Origin and Development of Storms, by H. H. Clayton (19 pp.). The author has prepared a summary of the chief results obtained by Loomis, bringing those bearing on each subject together and connecting them in a consistent whole.—An investigation of Cyclonic Phenomena in New England, by W. Upton (28 pp.). This is an attempt to make use of the material collected by the observers in New England as far as it relates to precipitation. especially to determine the peculiarities of its distribution in the separate storm movements. The period embraced, is from January 1885 to July 1886.—The connection between Meteorology and Terrestrial Magnetism, by R. Owen (5 pp.).—Weather Types on the Pacific Coast, by W. A. Glassford (10 pp.).—A Connecticut Tornado, by A. L. Rotch (7 pp.). This tornado occurred at Burnside village, on the Connecticut river, at 7 p.m. on September 12th, 1886. The peculiarities of this tornado were the absence of hail and the slight fall of temperature after its passage.—The Chinook winds, by M. W. Harrington (9 pp.). The author attempts to show that these winds are of the same character as the "Föhn," but exhibit the phenomena on a much larger scale.

ANNUAIRE DE LA SOCIÉTÉ MÉTÉOROLOGIQUE DE FRANCE. 84me Année. 1886, June-October. 4to.

Contains: Sur un enregistreur de l'intensité calorifique de la radiation solaire, par A. Crova (5 pp.).—Marche comparée de la pluie et de l'évaporation aux divers mois de l'année, par F. Houdaille (1 p.).—Halos extraordinaires vus au Parc-de-Saint-Maur, par E. Renou (1 p.).—Sur une nouvelle manière de représenter l'allure des températures à la surface de la terre, par M. Millot (2 pp.).—Sustentation des nuages dans l'atmosphère, par M. Hauvel (4 pp.).—Sur les pronostics relatifs aux gelées de printemps, par E. Renou (2 pp.).—Rapport entre la pluie d'été et le poids des récoltes de tabac dans le département de Vaucluse, par M. Maulbon (2 pp.).—Rapport de la nébulosité du ciel avec la hauteur du baromètre, par E. Renou (3 pp.).—Relation d'une ascension aérostatique effectuée à Clermont-Ferrand, le 20 juin 1886, par H. Lecoq (2 pp.).

BOLETIN DE LA ACADEMIA NACIONAL DE CIENCIAS EN CÓRDOBA (REPÚBLICA ARGENTINA). Tomo VIII. part 4. March 1886. 8vo.

Contains: Resultados de algunas mediciones barométricas en la Sierra de Córdoba por O. Doering (18 pp.).—La variabilidad interdiurna de la temperatura en algunas puntos de la República-Argentina y de América del sur en general por O. Doering. III. Variabilidad de la temperatura de Ushuaiá (44 pp.).

BOLETÍN DE LA SOCIEDAD GEOGRÁFICA DE MADRID. Tomo XXI. Nos. 8-4; September-October 1886. 8vo.

Contains: El huracán de Madrid, por D. V. Ventosa (17 pp.). A brief account of this tornado, which occurred on May 12th, 1886, was printed in the *Quarterly Journal*, Vol. XII. p. 214.

CIEL ET TERRE. REVUE POPULAIRE D'ASTRONOMIE, DE MÉTÉOROLOGIE, ET DE PHYSIQUE DU GLOBE. Deuxième Série. 2me Année. Nos. 15-20, October-December 1886. 8vo.

The principal Meteorological contents are: Les zones de température à la surface de la Terre (13 pp. and plate).—Les orages en France, par C. Ferrari (6 pp.).—L'océan glacial antarctique, par E. Lagrange (11 pp.).—La direction et l'extension du Gulf-Stream (8 pp.).—La tempête du 8-9 Décembre 1886, par A. Lancaster (11 pp. and 2 plates).

HANDBUCH DER AUSÜBENDEN WITTERUNGSKUNDE. Geschichte und Gegenwärtiger Zustand der Wetterprognose, von DR. W. J. VAN BEBBER. II. Theil. "Gegenwärtiger Zustand der Wetterprognose," 1886, 8vo., 508 pp. and plate.

The first part of this work was briefly noticed in Vol. XII. p. 219 of the *Quarterly Journal*. This volume forms the concluding portion. Although the present condition of weather prognosis is of practical importance to every one, Dr. van Bebber's book is of too technical a character for the general public, and is specially intended for the use of weather students.

The volume commences with a detailed description of the different systems of weather telegraphy in existence, and with a criticism of the advantages and defects of each. The various elements, so to speak, of weather, such as Temperature, Pressure, &c., are next treated, and the author then passes to a discussion of barometric maxima and minima, and their behaviour. It is this section of the book which presents the most interest, especially the portion which describes with great fulness the various tracks of depressions, and the effect of each on the weather of Central Europe. In this connection Dr. van Bebber constantly refers to what Woeikof terms the "Continental Axis," the ridge of high pressure which generally crosses Europe in a direction from west to east. Elaborate tables are given showing the probable success or the contrary of each prediction for each track in summer and in winter respectively. The whole of this, however, refers exclusively to German weather, and not to that of the British Islands. This section is followed by some deductions of a more theoretical nature; including suggestions for the general improvement of forecasting. The work concludes with a brief notice of the Law of Storms for sailors, taken chiefly from the Meteorological Office *Barometer Manual for Seamen*. The entire treatise is a valuable contribution to the science, especially as regards the results of Dr. van Bebber's own researches. It also contains full and interesting summaries of the theories and conclusions of the most important investigators of the various branches of weather study, and as it is furnished with a reasonably full index it will remain a very useful book of reference.

Memorie della Pontificia Accademia dei Nuovi Lincei, Vol. II. 1886, 4to.

Contains:—Studi sulle frequenza dei Venti e sulle relazioni della medesima coi principali elementi meteorologici, del Prof. D. Ragona (92 pp.).

Meteorologische Zeitschrift. Herausgegeben von der oesterreichischen Gesellschaft für Meteorologie und der deutschen meteorologischen Gesellschaft. Redigirt von Dr. J. Hann und Dr. W. Köppen. Dritter Jahrgang 1886, Hefte 10-12, October-December. 4to.

Contains:—Beiträge zur Kenntniss der Niederschlagsverhältnisse von Deutschland, von Dr. G. Hellmann (22 pp.). This paper is in two sections, treating respectively of the driest and wettest regions. The author finds that many of the older records are materially vitiated by faulty exposure of the rain gauges. He concludes that in North Germany there are three small areas with less than 20 inches of rainfall. In Southern Germany the driest part is the neighbourhood of Mainz (about 20 inches). The driest region of all is central Bohemia and the borders of Moravia, where some stations show only 15 inches.—Der Orkan von 14 Mai in Crossen a. d. Oder, von Dr. R. Assmann und Dr. W. Köppen (22 pp.). This is an account of a violent tornado which devastated the town of Crossen two days after the terrific storm which wrecked part of Madrid (May 12th).—Die Veröffentlichungen des Königl. Niederländischen Instituts, von Dr. J. van Bebber (5 pp.). This is a most useful account of the various works which have appeared in Utrecht, and which are for the most part almost sealed to English readers by their being in the Dutch language.—Ueber eine ungewöhnliche Anomalie zwischen gleichzeitigen Barometerständen von München und dem Wendelstein, von F. Lingg (4 pp.).—Reduktion des Barometerstandes auf den Meeresspiegel mit Hülfe einer graphischen Tafel, von G. Schubring (5 pp.). This is a proposal to substitute a graphical diagram for the tables at present in use. The diagram is very compact and intelligible.—Der Orkan vom 10 August 1886, bei Northeim und Catlenburg, von K. Dove (7 pp.).—Zur Polarisation des zerstreuten Himmelslichtes Beobachtungen über den Gang der neutralen Punkte, von F. Busch (8 pp.). This is an investigation into the position of the neutral points of Babinet and Arago. Riggenbach had found that when the sun is high, Babinet's point coincides with the position in the sun's vertical of the brightest point in Bishop's ring. The author finds by his observations that Babinet's point moves gradually away from the sun as it sinks, and subsequently approaches it.—Arago's point follows an exactly opposite course with regard to the antisolar point. Riggenbach finally has found that at sunset Babinet's point lies at the spot where the external limit of Bishop's ring was situated on the sun's vertical.—Angot's theoretische Untersuchungen über die Vertheilung der Wärme über die Erdoberfläche, von Dr. J. M. Pertner (7 pp.).

Michigan State Board of Health. Thirteenth Annual Report of the Secretary for the fiscal year ending Sept. 30th, 1885. 8vo. xxxviii. + 294 pp. 1886.

This contains an interesting report on the "Principal Meteorological Conditions in Michigan in 1884," by Dr. H. B. Baker, the Secretary (86 pp.). In addition to the compilation of reports by some thirty observers, Dr. Baker enumerates some of the uses of meteorological statistics in studying the causation of diseases, and also gives some reasons why so little is known of the meteorological causes of diseases.

Mittheilungen des naturwissenschaftlichen Vereines für Steiermark. Jahrgang 1885, 8vo. 1886.

Contains:—Ueber die Grundgesetze der Meteorologie. Zwei Vorträge, gehalten zu Graz am 7 Februar und 22 März, 1885, vom Prof. A. v. Miller-Hauenfels. (84 pp.).

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Band XCIII. II. Abth. May 1886. 8vo.

Contains: Bermerkungen zur täglichen Oscillation des Barometers, von Dr. J. Hann (14 pp.).

Symons's Monthly Meteorological Magazine. Vol. XXI. Nos. 249-251. October-December 1886. 8vo.

Contains: The Autumn Congresses (8 pp.). This article gives an abstract of the papers bearing on Meteorology which were read at the Meetings of the British Association at Birmingham, and of the Sanitary Institute at York.—Thunderstorms and heavy rains of September 3rd to 5th, 1886 (5 pp.).—Whirlwind and Waterspout in South Wales (2 pp.).—Remarkable Showers, by H. S. Wallis (3 pp.). This gives a number of extracts from the works of several of the leading writers on Meteorology on the subject of remarkable showers, e.g. milk, blood, sulphur, corn, animals, &c.—The recent Summer and the weather Cyclists (5 pp.).—Barometric depression of December 8th-9th (5 pp. and plate.)

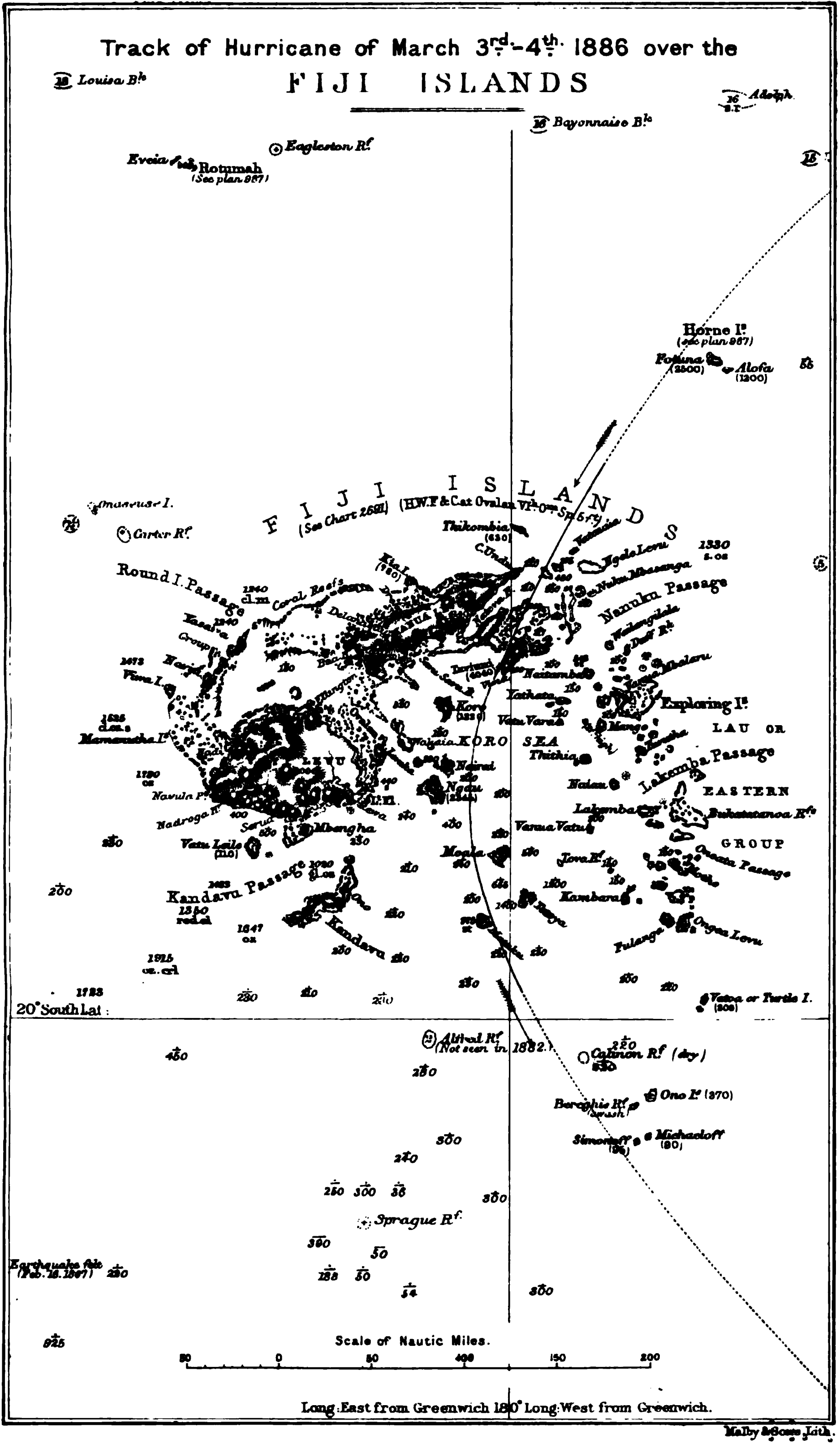
The Law of Storms in the Eastern Seas. By W. Doberck. 12mo. 1886. 24 pp.

The author says that "the origin of a typhoon is not quite understood, but appears to be connected with an abnormally high temperature and humidity in some place in comparison with the neighbourhood. Over such a place the hot air expands, ascends and is thereby cooled. But the heat liberated by the consequent condensation of water vapour retards the rate at which it cools on rising in the atmosphere, and enables it to rise still further. When the air has risen to a high level it effects there an increase of barometric pressure, in consequence of which the upper air is set in motion out towards the circumference of the area in question. Thus a fall in the barometer at the surface of the sea in the middle of the hot and damp region is effected, and the surrounding air is impelled in towards the centre. The motions inwards at the surface of the sea and outwards at a high atmospheric level are, of course, contemporaneous, and one is assisted by the other. But air in motion is deflected towards the right in the northern hemisphere, owing to the rotation of the earth, except at or very near the equator; whence typhoons do not exist in that locality, for if the wind continues to blow into the depression it is soon filled up. Owing to its deflection towards the right the wind is caused to move in a curved path in towards the centre, and the centrifugal force, developed in the curvilinear motion, deflects it still further from the straight line leading into the centre. The friction between the wind and the greatly disturbed sea-surface likewise retards the entrance of the air at the sea-surface into the central parts of the depression. But the air at a higher level in the atmosphere is subject to little friction, and escapes therefore at a greater speed from the central high-pressure area at that level. It is, therefore, apparent that once a cyclonal motion is started under circumstances favourable for its continuation, it tends to increase and to spread outwards. The progressive motion of typhoons is evidently caused by the wind prevailing, if not at the surface of the earth, at any rate at a higher level. That the principal part of the disturbance is situated high above the surface of the earth is proved by the fact that the centres of typhoons pass across mountains several thousand feet high."

Transactions of the American Society of Civil Engineers. Vol. XV. September 1886. 8vo.

This contains a valuable paper on "Evaporation" by Desmond FitzGerald (66 pp. and 12 plates). The experiments (which were made at the Chestnut Hill Reservoir, Boston Water Works) and discussions are confined principally to the natural evaporation from water surfaces. The maximum evaporation usually occurs on a cold day which has been preceded by warm weather. The hourly results show that the evaporation from a large water surface is nearly alike during the day and night.

Track of Hurricane of March 3rd-4th 1886 over the FIJI ISLANDS



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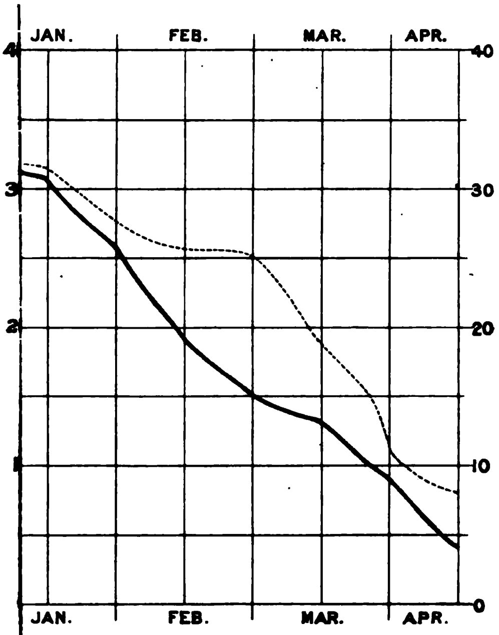
COUNTY OF SUSSEX.



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Royal Meteorological Society.

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SESSION 1887.

ORDINARY MEETINGS AT 7 p.m.

Wednesday,	January* ...	19,	1887	Wednesday,	May	18,	1887
,,	February ...	16,	,,	,,	June	15,	,,
,,	March	16,	,,	,,	November ...	16,	,,
,,	April.........	20,	,,	,,	December ...	21,	,,

* Annual General Meeting.

EXHIBITION OF INSTRUMENTS.

March 15th to 18th, 1887.

By permission of the Council of the Institution of Civil Engineers, the above Meetings will be held at 25 Great George Street, Westminster, S.W.

QUARTERLY JOURNAL

OF THE

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ADDRESS

DELIVERED AT THE

Annual General Meeting of the Royal Meteorological Society,

JANUARY 19TH, 1887.

BY WILLIAM ELLIS, F.R.A.S., of the Royal Observatory, Greenwich,
PRESIDENT.

IN addressing the Royal Meteorological Society on an occasion of this kind I feel to be in a somewhat anomalous position. I can hardly call myself a meteorologist, the greater and best part of my life having been spent in active astronomical pursuits. Of the literature and methods of astronomy I have had in my time opportunities of gaining some knowledge, and my sympathies with that science are necessarily strong. But having afterwards to turn my attention to other matters, meteorology among the rest, I fear that whilst I have scarcely kept up my acquaintance with the advances since made in astronomy, I have yet failed to arrive at a sufficient comprehension of what has been accomplished in meteorology, from the difficulty of grappling successfully with the vast accumulated and ever increasing stores of meteorological literature. Even those who have had opportunities of following with greater persistence the course of meteorological inquiry will, I think, be also ready to confess that it is not an easy thing to keep up a complete knowledge thereof. How, then, it appeared to me, could I address the Fellows of the Society in any worthy manner, or on what branch of the science could I venture to speak? An account or review of some special branch of meteorological inquiry might have proved interesting, but having been unable to undertake that examination of meteorological literature which such object would render necessary, I have felt constrained to content myself with putting together, in a perhaps rather disconnected way, some thoughts on matters which, if not altogether meteorological, may yet have regard to meteorology in its relations with, or to, other things. May I, therefore, ask you to contemplate for a time our science as one of others, and in its relations to others, in preference to considering it alone, or any particular division or portion thereof.

In earlier times we had our Royal Society receiving communications alike on all matters of science, and though at later periods other distinct societies one by one arose for the separate and, as was supposed, better study of different divisions of science, we now with increase of knowledge more completely see that the dividing lines are not so sharp. Each science has with and towards others relations which tend to its more effective development when properly kept in view. In fact, the successful prosecution of any one necessitates some acquaintance with and indeed the practical aid of others. The object of our own Society, the special advancement of meteorological science, would probably not be in any less degree secured by our attention being sometimes directed to subjects going beyond the limits of what may be considered technical meteorology. The physical sciences of astronomy, terrestrial magnetism, and meteorology are indeed intimately connected, besides which meteorology itself has especially close relations with natural science generally.

Mr. Hawksley, in the course of some remarks made at the meeting of the Royal Meteorological Society on June 16th last, after saying "that engineers "were greatly indebted to meteorologists for the information collected by "them concerning floods and rainfall," without which knowledge, as he continued, "it would not be possible for engineers to carry on their work "efficiently," proceeded to urge meteorologists "to investigate the causes of "the various phenomena connected with their science, and so increase the "practical utility of their work." We know that meteorologists have perhaps a good deal reversed the ancient order of things. The older philosophers indulged too much in speculation, but now there is said to be, as regards meteorology, an unnecessary multiplication of observations. Rather is it an unequal distribution of observers. Gratifying as is the testimony of Mr. Hawksley to the value of meteorological statistics, is not that which he urges continually present to the mind of every thoughtful meteorologist? Does he not constantly endeavour to act on such principle whenever he can see the way? How great an amount of labour has been already expended in many directions, if not always wisely at any rate with an energetic desire to trace out causes, with frequently disappointing and barren results. Neither is this surprising. Do we not all feel the peculiar difficulties with which we are confronted when, in dealing with the varied atmospheric phenomena of our globe, we attempt to deduce general laws, sometimes it may be (in spite of the multiplicity of observations of a certain kind) from the positive want of information impossible at present to obtain, as, for instance, better knowledge of the meteorological conditions of the upper atmosphere, and at other times from the difficulty of knowing how to deal with such facts as may be available, how to make use of them, discuss them, or proceed to build up therefrom.

Meteorology has been sometimes rather unfairly contrasted with the exact science of astronomy, and disparaging comparison drawn. But the few who might now be disposed to view meteorology in this way should themselves take in hand and endeavour to deal with some complex meteorological problem. They would then appreciate the difficulty attending such inquiries. No doubt it would be eminently satisfactory to be able to proceed in a more methodical manner than is generally possible. But the treatment can only be such as circumstances will permit. At nearly every step in astronomy strictly mathematical processes may be employed. Not so in meteorology, in the study of which tentative methods have had to a great extent to be relied on. The astronomer can do very much by himself, and may deduce important results from observations made entirely with his own instrumental appliances. The meteorologist, on the other hand, can do little alone beyond investigating the general peculiarities of his own observing station, although these may be to some extent an index of what happens over a considerable extent of adjacent country. The astronomer, from three independent observations of some comet never before seen, can calculate with considerable exactness its path through the heavens, and the time at which whilst visible it will reach any definite position. The meteorologist would only be too delighted could he, from the early observations of an advancing storm, foretell with corresponding precise accuracy its future though short-lived course. In the one case the prediction is a mere matter of rigorous calculation from fundamental theory, whilst in the other it rests rather on general experience gained by the tracking of many previous storms. We may, however, in some measure console ourselves by remembering that there was a time when even astronomy was passing through a like stage of development. Eclipses of the sun and moon, for instance, were in remote ages predicted simply from their having been previously observed to recur in a certain order, in ignorance of their exact theory. If the confessedly difficult subject of meteorology be passing through a similar experience,—if we have yet to a great extent to feel our way rather than see it,—may we not believe that in this direction, as in others, knowledge by a process of evolution will increase, so that in time we, or our successors, may pass from present systems to others more logical. How improvement may come and to what extent we do not know, but that there will be advance the history of all science abundantly proves. Besides, in meteorology itself there has been distinct progress. Cast a glance backward. Compare the present knowledge concerning atmospheric changes and storms with that existing a generation ago. It is not so many years since the preparation of daily synoptic weather charts giving graphic representation of the meteorological conditions existing over considerable areas, and within a few hours of the necessary observations having been made, would have been impossible, but now that, by the aid of the electric telegraph,[1] this is accomplished, we have become so familiar with, and accustomed to, these charts that we fail to realise the superior position in which in this respect, as regards land observations, we stand, or the power which has thus been placed in our hands. And even if our knowledge of laws and principles be not yet greatly increased, we may hope that, should the foundations of meteorological science be only slowly laid, the structure to be erected thereon will prove all the more complete.

In further contrasting astronomy with meteorology it may be remarked that the astronomer deals with phenomena external to the earth, and any observations which he may secure can, when necessary, be readily made independent of his own particular position, for combination with other observations, by reduction to the centre of the earth. But the meteorologist, recording conditions existing at that point on the earth at which he happens to be placed, finds those conditions, as regards direct comparison with those existing at other places, influenced in a variety of ways. Thus whilst the diurnal change of the meteorological elements is different at different places in a way at present only to be discovered by observation, it will in a different longitude have also reached a different phase, the local day being more or less advanced, besides which the elevation above sea-level must also be taken into account. Again, in astronomy, the power of assimilating observations, if I may so express it, is mostly in advance of the observational power, requiring ever greater instrumental means, which, when supplied, only bring to light newer relations calling again for more extended and yet more powerful instrumental means, in this way tending to increase in many directions our astronomical knowledge. But in meteorology it is different. Here instruments can in general be constructed in advance of the power of making corresponding adequate use thereof, and we are confronted with observational difficulties at the outset. Thus we can construct mercurial thermometers on which we can rely to the one-tenth part of a degree, but how are they to be exposed in order to obtain the true temperature of the air? Or, having become satisfied that our anemometer as an instrument is trustworthy, how place it so as to get satisfactory determinations of the velocity of the wind, or how expose properly our rain-gauges? But though the meteorologist is thus troubled, the astronomer in one respect does not quite escape, the element of temperature being to him a great enemy, one with which he has in various ways to reckon. It may disturb the rate of his clock, on the exact going of which, in fundamental astronomical work, so much depends, besides which the temperature of the air, so difficult to obtain satisfactorily, is an important factor in the calculation of astronomical refraction. And in some species of astronomical inquiry involving measurements of delicate character, temperature effects are especially a source of trouble. One other fact it may be interesting to mention. The great transit circle of the Royal Observatory, Greenwich, although one of the most massive and firmly mounted of modern astronomical instruments, yet feels the effect of temperature, the inclination of its axis, technically known as the " error of level," varying from day to day in close accord with the variations of temperature: its value can, however, at any time be readily observed.

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[1] This is one of various subsidiary uses of the electric telegraph scarcely contemplated on its first establishment. Other such uses are its employment for the distribution of accurate time, so necessary for the proper regulation of the involved traffic of our railways, and in astronomy the very powerful aid it has afforded for the more exact determination of geographical longitudes.

Still bearing in mind the relation between astronomy and meteorology, let us for awhile consider some of the more ancient and, in some sense, still popular ideas in regard to weather change. The motions and periods of the heavenly bodies have ever attracted the attention of mankind, and, the general march of our seasons closely following and clearly depending on the annual period of the sun, it would naturally be anticipated that the more rapid changes of weather must in like manner be due to or dependent on astronomical influences. But, beyond the diurnal and annual periods of the sun, the special solar aspects were all too few and far between to find any sufficient number of such wherewith to endeavour to connect weather change. The popular belief in the more stormy character of the equinoctial periods has been recently shown, as concerns our latitudes, to be an erroneous one, as might have been expected. A more extravagant popular idea was that which supposed that the wind or weather prevalent on the day of the spring equinox would continue for a certain period. In fact, as regards ordinary variations of weather, the sun in this connection was an impracticable body having no sufficient number of phases or periods on which to ground arbitrary theories, in the endeavour to discover which his real influence as the great agent in all weather phenomena was not properly realised. And so it became necessary to seek for other explanation of weather change. The next celestial body in apparent importance, the moon, and more especially on account of her ever-changing aspect and apparently irregular motion, would thus naturally engage attention. We know how strong has been, and indeed still is, the popular impression that the commonly called " changes of the moon " produce or are accompanied by marked changes of weather, and how frequently against such impression neither evidence nor argument will convince. It avails not to explain that the " first quarter " of the almanac is simply an indication of the fact that the astronomical longitudes of the sun and moon differ by 90°, the passing through which position by the moon can produce no sensible effect on the weather. Neither is it realised that the weather may clear up on a given day in one part of the country but still remain bad in another part, all under the same so-called change of the moon, as though her action could be so entirely different at places not widely apart. Or, to put the matter in another way, what varied effects must the moon at the same instant appear to produce at places on opposite sides of an advancing cyclone.

Such notions of distinct lunar influence may have been in some degree fostered by the custom of popularly speaking of the changes of the moon rather than of the phases of the moon, and so half suggesting some connection with changes of weather. But the study of a weather chart should dissipate these notions, which could probably only arise in a country in which weather changes are very frequent.

The attempts made in later times to unravel weather irregularities, and discover some connection between lunar motions or positions and weather, or any element thereof, as atmospheric pressure, rain, &c., were somewhat more philosophical, but have led to no practical result; and, desirable as it may have been that investigations of the kind should have been undertaken, the amount of time and labour that have been expended thereon will probably have been quite beyond what was necessary to determine satisfactorily whether any definite or measurable relations exist. But the endeavour to discover weather cycles or periods, not only solar and lunar, but also planetary, not only probable, but also apparently of the most improbable kind, seems to have exercised altogether a fascinating influence. We know how small and comparatively insignificant, and in no way interesting except in a philosophical sense, are the relations which have actually been deduced between lunar periods and different meteorological elements; knowing, also, how violent are the atmospheric disturbances that from time to time occur, the conclusion is unavoidable that unless sufficiently confirmed by independent inquiry, little reliance can be placed on resulting slight variations of elements subject to such extreme accidental disturbance, the conditions being altogether unfavourable to the determination of any inequality whose magnitude is small. Out of all the mass of well and ill directed inquiry of the character described, the principal fact that has been definitely established and independently confirmed appears to be the existence in tropical regions of a small lunar atmospheric tide. The tendency to dispersion of cloud under the influence of a full moon, considered by various authorities to be a fact of observation, but without, so far as I am aware, any numerical evidence having been ever adduced in its support, is, I believe, as regards Greenwich, a fallacy, as I have myself endeavoured many years ago to prove. In this connection it has been attempted to be shown that the temperature of the air is on the average sensibly lower about the third quarter of the moon than at any other part of the lunation, and it might be well that some independent endeavour should be made either to confirm or disprove the existence of such effect.

A good deal of attention was paid by earlier meteorologists to general climatology, and every credit is due to them for all that they have accomplished with the information and materials at their command; for indeed they must have found that, for want of sufficient data, meteorological inquiry was greatly limited. Happily, the meteorologist of our day has found a wider sphere of work in the opportunity that has been afforded him of studying more completely, and on a scale and to an extent that was impossible until the construction of synoptic charts, the complex and broad phenomena of our atmosphere in all its varied relations, leading the way at last to some definite knowledge in regard to what is going on from day to day therein. Such study of the general phenomena of weather, whilst of practical aid in forecasting, marks also an advance on older methods of proceeding. Further inquiry, however, creates further wants. Twenty-four hours is a long period, and, in a scientific if not in a practical point of view, a more frequent preparation or publication of synoptic charts, at any rate in critical cases, might now be desirable. The system of collecting and independently publishing in different countries statistics in regard to rainfall is another growth of modern times, and, as accumulating facts of observation of the most valuable kind, the system is one that we should all desire to see extended to the greatest possible extent. Allusion may also be made to the greater attention now in many ways given to the phenomena of clouds, a study which, affording information useful in forecasting, adds also to our knowledge in an interesting field of meteorological inquiry.

Reverting now more particularly to the sun, the central body of our system, and in reality the dominating influence in all meteorological phenomena, be they periodic or otherwise, and referring to a previous remark on the intimate connection existing between meteorology and terrestrial magnetism, a comparatively new science as compared with astronomy and meteorology, let us consider a little the relations and contrasts existing between them.

Now it has been found possible to form a general theory of terrestrial magnetism such that the observed values of the various magnetic elements at different places on the globe may be closely represented by calculation. Not so, however, as regards the meteorological elements of the surrounding atmospheric envelope. But between variations of the elements there are certain interesting relations. We find, for instance, that as there exists in our latitude a diurnal variation in the meteorological element of temperature, attaining its extreme limits at different periods of the local day, so also is there a diurnal variation of similar character in the position of the magnetic needle.[1] And as the daily range of temperature is greater in the summer than in the winter months, so also is the daily range in the position of the magnetic needle greater in summer than in winter, with a tendency to an increased range in spring and autumn, a peculiarity not observed in temperature in which the summer range is absolutely the greatest. In the southern hemisphere the daily range of temperature and the daily magnetic range are conversely both small in our summer and large in our winter, the winter and summer respectively of southern regions.[2] Further, in the position of the magnetic needle there is a slight progressive change from year to year, part of a long period variation. There may be also a secular change of temperature, but if so, its amount appears to be so small as not to be definitely measurable for the time during which observations of temperature of any sufficient accuracy have been made. Then there are the irregular magnetic disturbances or magnetic storms, which have their counterpart in atmospheric storms, but with a difference. A severe magnetic storm is usually felt simultaneously over the whole earth, whilst an atmospheric storm has a local character, travelling successively from place to place. Thus in a most violent atmospheric storm at any particular place the magnetic needle may be perfectly quiet as regards anything like storm movements; conversely the needle may be greatly disturbed, that is, a violent magnetic storm may occur on a day that is atmospherically quite serene, excepting that there may be some display of aurora. To this matter, however, we shall again recur.

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[1] The same thing is true of the magnetic elements generally, but for simplicity of statement the reference above is confined to the ordinary declination or compass needle.

[2] It may be mentioned that as regards lunar diurnal inequalities there appears to be a small but distinct magnetic inequality, but no sensible temperature inequality.

To understand better certain other analogies and contrasts between meteorology and magnetism, let us consider in one respect somewhat of the physical condition of the sun. The existence of small black spots seen from time to time on the solar surface is known to all, also that they vary both in number and magnitude. By counting up the number of spots at any time visible, or by measuring their areas, a numerical estimate of the condition of the sun on any day as regards spots may be obtained. In this way numbers have been found which indicate relatively the variations that occur from day to day, which numbers, being tabulated through a series of years, disclose an alternate rise and fall in the values, such that the interval between successive maximum or successive minimum values is on the whole about eleven years. This has come to be known as the eleven-year sun-spot period, a misleading term, however, and one that has produced misconception. For the intervals between successive maxima or successive minima may be a year or two more or less than eleven years, the fact being that the observed intervals cluster about an eleven-year value without apparently following any particular order of increase or decrease, so that at present it is not possible from previous observation to say precisely what the length of the next interval may be. It is seen that the spots are increasing or decreasing, but the epoch of a following maximum or minimum is to a certain extent indefinite, becoming precisely known only when actually observed. Further, an epoch of minimum sun-spots is not equidistant between the epochs of the two adjacent maxima; neither, of course, is a maximum epoch equidistant between those of two adjacent minima, the interval from maximum to minimum being considerably greater than that from minimum to maximum, as much as two years on the average. Mention might be made of other circumstances of extreme interest in relation to the formation and behaviour of solar spots, but we cannot enter further into the subject here. What has been stated is sufficient for the consideration of such matters as we are likely now to discuss.

No satisfactory explanation has been given of the cause of the rise and fall in the number and magnitude of the solar spots, and although attempts have been made to show that this may be due to action or influence from without, it would rather appear to be connected in some way more closely with the sun itself. But whatever may be the inducing cause, it is clear that the obscure action thus visibly indicated to us on the solar surface, influences also our distant earth, on which effects are produced in sympathy therewith. I have said that the diurnal variation in the position of the magnetic needle is greater in summer than in winter. But further, when sun-spots are numerous its value becomes increased, and when sun-spots are few it is diminished, throughout the year, the summer and winter ranges of the needle being both respectively increased and decreased, and in no inconsiderable degree, for the diurnal range of the needle in years of maximum sun-spots may be twice as great as in years of minimum sun-spots. The two things go quite together; when the interval from maximum to minimum or from minimum to maximum of sun-spots is long, the interval between the corresponding epochs of extreme magnetic range is also long, and when one interval is short the other is also short. This hanging together in the varying length of the intervals from maximum to minimum or from minimum to maximum in both phenomena is the really conclusive test of sympathetic connection, and is a feature of the case to which sufficient consideration has not always been given. The comparison of a mean sun-spot period with a mean magnetic period, determined each from observations extending probably over different series of years, would naturally be unsatisfactory, considering how the length of individual intervals vary. The accordance between the corresponding intervals or periods in the two phenomena is, as I have said, the convincing proof of connection. It has been thought that the magnetic effect somewhat follows the solar effect; but this is a point which probably requires further examination. In other respects newer investigations by different people, from observations made at different places, entirely confirm the old in all their broad features. The extent to which the magnetic diurnal range varies with varying sun-spots is such as would lead us to suppose that the variations of solar spots may be to us only the visible manifestation of great solar disturbance in regard to which we have yet much to learn.

The existence of this intimate sympathy between the variations of solar spots and terrestrial magnetism naturally suggested the great probability of connection also with meteorology, and many efforts have been made to discover whether such of the meteorological elements as atmospheric temperature, rainfall, &c. show to any measurable amount corresponding sympathetic variation. The magnetic variations appear to be in a great degree similar over a considerable portion of the earth, so that phenomena observed at one station become typical of what occurs generally; but in meteorology the atmospheric circumstances vary with geographical position to such an extent that the phenomena observed at one station are not in the same sense typical, which renders the inquiry more complex, besides which the problem may not have been attacked in the best way, from the want of sufficient material for any complete investigation. Still, as regards temperature, attempts have been made in various ways and for a considerable number of stations to detect a relation with sun-spot change, but so far apparently with but small success, the results obtained being numerically somewhat insignificant, without exhibiting that degree of accordance which would allow us to form any conclusive opinion, excepting indeed that if there be any measurable effect its magnitude, unlike the magnetic effect, is small. As regards rainfall, whilst the evidence appears in some respects to show probability of increased rainfall with increase of sun-spots, the results still appear to be to some extent conflicting. But when we come to a different class of phenomena—when, for instance, we are asked to admit a corresponding marked variation in the price of food and a connection with recurring famines—we get on yet more doubtful ground. For we should imagine these things to be influenced by variations in temperature and rainfall. But if it be still uncertain whether these elements have any very perceptible relation with sun-spots, we should hardly be prepared to expect such other matters as those mentioned to show any striking correspondence, not to speak of the possibility of their being also largely influenced by artificial causes. For, admit that in certain regions the effects mentioned exist; admit, also, that in the same regions the sun-spot inequality is, on the whole, accompanied by some corresponding variation in temperature and rainfall. The question then seems to be, can minor fluctuations in meteorological conditions really be so great a determining factor in the cases in question. For if so, since greater like causes should produce greater like effects, how much more perceptible should be the influence of those periods of greater and more extreme variation of temperature and rainfall which occur as it were irregularly, although according to some law, but yet apparently without relation to the sun-spot period. Are not these greater variations of inducing causes much more likely to prove to be the prime agent in producing all effects, including also those which have been supposed to be related to sun-spot change.

It is of course important that investigations such as those to which attention has been drawn should be undertaken, and thanks are eminently due to those who, voluntarily taking upon themselves such laborious work, have done the best with the materials at their command. The whole subject, however, as regards connection between sun-spot variation and meteorology, or subjects influenced by meteorological conditions, seems indeed incapable of satisfactory treatment until a better knowledge of the meteorology of the globe has been obtained. For whilst the investigations hitherto made have been necessarily more or less of partial character, the deduced variations of meteorological elements are not of such magnitude as to be self-evident, that is to say, it is so much a matter of individual judgment whether the residual quantities in the various investigations really indicate a physical law, or whether they are simply accidental in nature owing to insufficiency of data. The establishment of any meteorological relation, even if insignificant in magnitude and practically unimportant, would be philosophically of extreme interest; but at present, in regard to the whole subject, an attitude more or less of reserve seems to be the proper position to assume, since too hastily to accept uncertain or unconfirmed results is to depart from the true spirit of scientific inquiry. Our knowledge is ever surrounded by a borderland of doubt, to be encroached upon only by steps which, if slow, must be sure.

As further illustrating the comparative uncertainty of our knowledge as regards connection between sun-spots and meteorology with the pronounced character of the broad relation[1] existing with terrestrial magnetism, let any person unaware of the sun-spot variation be asked to extract from a long series of photographic magnetic registers those in which the diurnal curves are the most bold or magnetic disturbances the most frequent, and he would naturally be led to fix on years in which sun-spots were numerous. And the years of small magnetic change he would find to be years in which sun-spots were few. But no similar distinction can be drawn between the curves of any meteorological element, showing the greater relative magnitude of the magnetic effect as compared with any probable meteorological effect.

So far as regards the more regular variations. Some reference has already been made to storms, but a few words may be here added. Atmospheric storms travel over a considerable portion of the earth's surface and are felt successively at different points thereof, having thus a local character, but the great magnetic storms, on the contrary, have a more cosmical character; being felt simultaneously at widely different portions of the earth's surface, and when, as is not unfrequently the case, a storm lasting perhaps for many hours breaks out very suddenly after a quiet magnetic state, the first manifestation will occur in the most abrupt manner at the same moment of absolute time in countries and places as remote from each other as Canada, England, China, Australia and Cape Horn, the whole earth, as it would seem, being simultaneously affected in a most remarkable way. How is such sudden outbreak to be explained, and what kind of action can it be that produces these startling effects. Such storms are greater and more frequent about the epochs of sun-spot maxima, and there has been reason to suppose that they are intimately connected with solar disturbance. Undoubtedly great magnetic storms do frequently occur when very large spots are visible, but what the precise relation may be is a matter requiring yet further attention. We possess continuous magnetic registers; could we obtain a similarly continuous knowledge of solar change, some light might perhaps be thrown upon this difficult point. We find the magnetic registers at any given place to be, on some days quiet, showing only the ordinary local diurnal change; at other times there will be small motion occurring nearly at the same time on different days; sometimes there will be a continual small fretting of the curve, and at other times a more or less disturbed state existing for several days; and finally there are the great storms. Such are some of the broad characteristics of these registers, and the question is, how far can we separate the effects, and say which of them are simply diurnal or peculiar to the station, and whether any and which are general and related to or dependent on distinct solar change. The aurora, when visible in our latitudes, is always accompanied by magnetic disturbance, its appearance being indeed subject to a periodicity similar to that of sun-spots, and caused apparently by periodical shift of the auroral zone.

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[1] Attempts have been made to advance further our knowledge in regard to magnetic variations and show correspondence with solar phenomena in minor details, but hitherto, it must be admitted, not with great success.

Terrestrial magnetic storms being unquestionably more numerous about the years in which sun spots are most numerous, endeavour has been made to show that our atmospheric cyclones follow also a similar law; but here again the inquiries have so far been probably of too partial a character to permit any definite conclusion to be drawn.

Some reference should be made to earth currents, which, intimately connected with magnetism, may, it has been thought, have also some meteorological connection. If an insulated telegraph line, long or short, be erected, and its ends connected each to a metallic plate buried in the earth, it will be found, on placing a delicate galvanometer without battery in circuit, that galvanic currents, spontaneous as it were, and more or less strong, will be continually passing. Such currents, termed earth currents, show diurnal variations in the same way as does the magnetic needle or the meteorological element of atmospheric temperature, and similarly the magnitude of these earth current variations, although relatively small, appears to be also greater in summer than in winter. But what I particularly wish to remark is, that in all cases of magnetic storm there is also earth current storm, the relation in this respect between magnetic activity and earth current activity being of the most intimate character.[1]

Thus there are four forms of energy apparently closely related, and having common origin, as it would appear, in the sun. These are the solar activity indicated by the varying sun-spots, magnetic disturbance, earth current activity, and auroral phenomena. The magnetic and earth current effects are clearly due to solar influence, exerted either directly on the earth, or, as has been conjectured, by increased solar radiation disturbing the electrical condition of the atmosphere, and thereby giving rise to earth current and magnetic disturbance. In the magnetic disturbances recorded at Greenwich the motions of the magnets do appear to be such as would be produced if the accompanying earth currents acted upon them in the same way that a galvanic current influences a suspended horizontal magnetic needle when the current passes through a wire placed below it, and magnetic disturbances are always accompanied by strong earth currents. It must, however, be admitted that the ordinary diurnal magnetic variations do not appear to be such as would similarly be produced by the corresponding earth currents, not to speak of their comparative weakness as compared with those which accompany magnetic disturbance. Indeed, the precise character of the relation connecting together these various phenomena is still in a great degree matter for inquiry. Be the action, however, independent of the atmosphere or by means of the atmosphere, we see that the meteorological elements, so far as it has been possible to discuss them, if at all influenced by solar spot activity, are so affected only in a comparatively slight degree.

I do not propose at present to pursue this subject further. In spite of what I said at the commencement of these remarks, the Fellows will, I fear, think, and perhaps justly, that in the name of meteorology I have only used the occasion to speak about quite other things. I feel that this is very much the case, and in explanation can only say that with some of the matters treated I have, at any rate, a certain personal acquaintance. Besides, it seems good sometimes to wander away a little from meteorology proper. Few of our Fellows, I imagine, would like to see the Phenological Report and some other matters drop out of our volume, and although we might travel too far in other directions, we have not yet I think erred very greatly in this way.

What most concerns and interests us, however, is the present outlook as regards meteorology. When we consider the marvellous advance made during the last half century in our knowledge of the physical sciences generally, and especially in those of astronomy and electricity, we are sometimes inclined to think that meteorology as a science becomes yet more outstripped in the race. And yet we should not be disappointed, for here too we shall see advance if we compare the meteorology of fifty years ago with that of to-day. Those who preceded us worked well in various directions with the materials available to them, but we possess superior advantages, of which it is to be hoped we are making as good use. Our field of observation has been much enlarged, rendering it now possible to attack meteorological problems in a more complete manner than before. But much is yet required. In many regions of the earth information on the meteorological conditions yet wanting may be in time supplied, but the question of ocean meteorology is more difficult, as also is that of ascertaining the meteorological conditions of the atmosphere high above the surface of the earth. The observatories established on elevated positions have probably not altogether met the latter want, independently of their necessarily limited number. Still, in spite of difficulties, a new and higher meteorology has in later times been springing up, making of meteorology more a science in fact as well as name. This is shown not only by the valuable memoirs published by different Government authorities, as well as by meteorologists generally, but also in the character of the newer meteorological treatises and text books. The various international congresses that have from time to time been held, have no doubt promoted uniformity of action and division of labour to a certain extent, though we still find in different countries different units of measure. But now perhaps more than ever meteorology calls for combined action among its workers. Of late we have heard much in various directions of federation. Might not a permanent federation of the meteorologists of acknowledged authority in different countries regulate meteorological action and inquiry throughout the world, deal with new questions as they arise, and encourage everywhere unity of action and division of labour, thus promoting the better elucidation of meteorological laws, whilst also accumulating materials for the future discussion, not only of the meteorology of the earth as a whole, but also of any periodical or secular changes, however produced, that may be proceeding thereon.

REPORT OF THE COUNCIL.

FOR THE YEAR 1886.

This has been a comparatively uneventful year in the history of the Society; but it has nevertheless been a year of steady work, in which the Council have been materially assisted by the Committees appointed at their first meeting.

The Committees were thus constituted:—

General Purposes Committee:—The President, Secretaries, Foreign Secretary, Treasurer, Mr. Latham, Mr. Laughton, Mr. Whipple, and Dr. Williams.

Editing Committee:—The President, Mr. Inwards, Mr. Scott, and Mr. Whipple.

Annual Exhibition Committee:—The President, Secretaries, Foreign Secretary, Dr. Marcet, Mr. Strachan, and Mr. Whipple.

Experimental Research Committee:—The President, Secretaries, Foreign Secretary, Mr. Archibald, Mr. Benn, Mr. Eaton, Mr. C. Harding, Mr. Laughton, Mr. Russell, and Mr. Whipple.

Decrease in Water Supply Committee:—The President, Mr. Chatterton, Mr. Latham, and Mr. Symons, with Mr. Scott, representing the Meteorological Council.

Wind Force Committee:—The President, Secretaries, Foreign Secretary, Mr. Archibald, Mr. Chatterton, Mr. W. H. Dines, Mr. C. Harding, Mr. Laughton, Mr. Munro, Mr. Peek, Mr. Stanley, and Capt. Toynbee.

The Wind Force Committee have not yet concluded their labours, but have presented a preliminary Report, which will be read at the April Meeting of the Society.

The Committee for investigating the Helm Wind on Cross Fell was not re-appointed, but merged in the Experimental Research Committee. A scheme for obtaining more information in regard to this phenomenon was arranged in concert with the Penrith and District Literary and Scientific Society during the preceding year. A number of volunteer observers resident about Penrith are prepared, on receiving notice of the occurrence of the Helm Wind, to assemble at different points to make observations thereon; but although on several occasions during the course of the year such notice was given, it unfortunately happened on such occasions that the phenomenon was transient and had disappeared before the observers could commence operations. Twelve sets of sling dry and wet thermometers, as well as several other instruments, have been lent by the Meteorological Council to the various observers to aid them in the prosecution of the inquiry, in which our Fellow, Mr. T. G. Benn, has shown great interest.

In the early part of the year the Council took into consideration the cost of the Journal and the paper on which it was printed. The Committee to whom the matter was referred obtained tenders from various well-known firms. Eventually new arrangements were made with their present printers, who agreed to make some reduction in their charges, and use better paper.

A decided saving has thus been effected in this important item of expenditure, as well as an improvement in the Journal itself. The alterations in the *Meteorological Record* (by the omission of the Tables of Symbols and the addition of a Table of Daily Rainfall for several selected stations) have also been carried into effect, in accordance with the decision announced in the last Report.

A letter was received in May from the Meteorological Council, stating that they contemplated abandoning the reading barometers to 0·001 inch, and instructing their observers to read to 0·01 inch only, and requesting the opinion of the Council of this Society on the subject. At the next Council Meeting it was resolved that the reading of barometers to the third place of decimals was not essential, but that the observers of the Society be left to follow whatever practice they prefer; and a reply to that effect was sent to the Meteorological Council.

The Exhibition of Barometers, held in the Library of the Institution of Civil Engineers on March 16th-18th, was a very successful one, being both valuable and interesting. There were 78 barometers, 9 new instruments, and 33 photographs, drawings, &c., making a total of 120 exhibits. The instruments were classified as follows:—Mercurial Barometers—Adjustable Cisterns, Closed Cistern, Siphon; Barographs; Aneroids; and Metallic, and other forms of Barometer. A descriptive Catalogue, together with a sheet of illustrations, has been published in the Journal, as well as the exhaustive paper, "Brief Historical Account of the Barometer," by the President.

The thermometric observations on Boston Church Tower having been continued for two years, a valuable series of observations has been obtained. The cost was defrayed from a grant of £25 procured through Mr. Symons from the Royal Society; a small deficiency, not exceeding £8 10s., has been made good by our Society. The result is satisfactory, and the observations will, as soon as possible, be worked up by Mr. Marriott. An offer was received from Mr. H. Mantle, F.R.Met.Soc., of the Lincoln Diocesan School, to carry on a similar investigation on the Great Tower of Lincoln Cathedral. As Mr. Mantle was in every way competent, and the Dean and Chapter had given permission for the Electrical Thermometer to be erected on the Tower, it was decided to transfer it with the other instruments from Boston to Lincoln. This was accordingly done by Mr. Marriott in June last; the expense of the removal being defrayed out of a further grant of £20 from the Royal Society.

It will be in the recollection of the Fellows that in the year 1884 a Committee was appointed to investigate the subject of the brilliant sunrises and sunsets first observed in the autumn of 1883; and in the Report of the Council for that year it was stated that "The Royal Society, at a date subsequent to the appointment of the above Committee, nominated a Committee of their own to examine the entire question of the eruption of Krakatoa and the attendant phenomena, and as the Royal Society Committee had collected a large mass of information bearing on the sky coloration above mentioned, the Committee of this Society gladly accepted the invitation conveyed to them in the month of October, that its members should be co-opted into the Royal Society Committee, and that they should undertake the discussion of the entire mass of material bearing on that branch of the subject." The Krakatoa Report has not yet been published, but the Council have been glad to learn from the Presidential Address to the Royal Society, delivered at the Anniversary Meeting, November 30th last, that "the heaviest part of the Report, that relating to sunsets and atmospheric phenomena, has been prepared by the Hon. Rollo Russell and Prof. Archibald, the two Fellows of the Royal Meteorological Society who have been mentioned as having been added to the Committee, and is ready, with the exception of a little revision."

Letters were received from the Foreign Office and the Local Government Board, containing copies of documents relative to the International Congress of Hydrology and Climatology which was held at Biarritz in October last. The Society exhibited at the Congress a collection of its publications, and has been awarded by the judges a Diplôme d'Honneur. Mr. Symons and Mr. Inwards unofficially attended the meeting and excursions, and at the December Meeting of the Society the former read an interesting account of the visit.

There have been several alterations in the Society's stations during the year, returns having been accepted from Exeter, Great Berkhamsted, Harrogate, Lincoln and Rousdon, whilst those from Boston, Isleworth, Maker, St. Michael's-on-Wyre, Southend, South Norwood and Strelley have been discontinued.

The usual inspection of the Stations has been made by Mr. Marriott, who has this year visited those in the South-west of England and Wales, as well as Addiscombe, Beddington, Lincoln, Marlborough and Wakefield. With a few exceptions, all were found in a satisfactory condition. Mr. Marriott's Report will be found in Appendix I. p. 118.

As the pamphlet entitled *Hints to Observers* was out of print, the Council decided to revise and reprint it with some small additions and illustrations. The new edition consists of a thousand copies, of which one is to be sent to each Fellow and one to each observer, the remainder being kept in stock for sale.

The Papers printed in the *Quarterly Journal* have dealt with important subjects, and the Council trust that they may be of value. The Meetings have been well attended, and the newly introduced rule of allowing each speaker only five minutes, except by special permission, has worked satisfactorily. Even with this restriction the business has with difficulty been got through within the allotted time.

The Library has received considerable additions during the year, chiefly by presentation or exchange. The sum of £25 has been expended in binding, and in the purchase of books. A list of presentations and exchanges will be found in Appendix V. p. 129.

The Council have to announce with much regret the death of one of their former Presidents, Dr. Mann, who took great interest in the work of the Society. He served the offices of President and Vice-President, and was for many years Member of Council. He was also a member of several special

Committees, notably the Lightning Rod Committee, to the work of which he devoted much time and consideration. Twelve other Fellows have also been removed by death, and one Honorary Member, Mr. G. T. Kingston, M.A. The list of deceased Fellows is as follows:—

William Adams, M.Inst.C.E., F.G.S.	elected in the	Society	Feb. 21, 1877.
James R. Croskey, F.R.G.S.	,,	,,	Jan. 21, 1863.
Henry Culley	,,	,,	April 18, 1883.
John William Eccles	,,	,,	Feb. 17, 1864.
Samuel Collett Homersham, M.Inst.C.E.	,,	,,	May 7, 1850.
William Frederick Ingelow	,,	,,	Nov. 19, 1862.
Rev. Clifford Malden, M.A.	,,	,,	May 19, 1886.
Robert James Mann, M.D., F.R.A.S.	,,	,,	March 20, 1867.
Thomas Mann	,,	,,	June 4, 1850.
John Maule Sutton, M.D.	,,	,,	Feb. 17, 1875.
Rev. Samuel Kirke Swann, M.A., F.R.A.S.	,,	,,	May 19, 1880.
A. Henry Taylor	,,	,,	May 19, 1880.
F. Gartside Tippinge	,,	,,	May 16, 1877.

The following table shows the changes that have occurred in the number of Fellows during the year:—

Fellows.	Annual.	Life.	Honorary.	Total.
1885, December 31 ...	381	135	19	535
Since elected	+22	0	0	+22
Since compounded.... .	– 1	+1	...	0
Deceased	–10	–3	–1	–14
Retired	–15	...	...	–15
Defaulters	– 4	...	...	– 4
1886, December 31 ...	373	133	18	524

In the Report for 1883 it was stated that in consequence of a very general feeling that the income of the Society was insufficient for its work, and that its usefulness was likely to be seriously curtailed by want of funds, the Council recommended the Fellows to increase the subscription from £1 to £2 per annum, and the life composition fee to a nearly corresponding extent. This step was felt to be of great importance to the future of the Society, although it was impossible to forecast with any certainty its effect on the number of the Fellows. The Fellows were consulted by Circular as to their opinion of the change, and the answers were generally favourable. It was proposed to allow Fellows elected previous to January 1st, 1870, to continue on the old subscription, and it was thus hoped that the number of Fellows would not be materially reduced. The results of the three years' experience are very satisfactory, as in 1883 there were 419 Fellows making annual payments against 395 in 1884, 381 in 1885, and 373 in 1886, showing a reduction of 46 only, whilst the subscriptions in 1883 were only £425 8s. against £756 9s., £694 11s., and £674 19s. respectively in the three subsequent years. These figures do not, however, show the precise extent of the change, as no less a sum than £199 10s. was paid in 1883 and £135 in 1884 as composition fees by Fellows at the old rate of composition. The total number of Fellows in 1883 was 568; in 1884, 551; in 1885, 535; and in 1886, 524; showing a comparatively small decrease.

The total receipts in 1883 were £870 12s. 10d.; in 1884, £1,195 11s. 6d.; in 1885, £934 4s. 5d.; and in 1886, £958 8s. 11d. The expenditure in 1883 was £766 0s. 11d.; in 1884, £981 7s. 8d.; in 1885, £943 11s. 11d.; and in 1886 £860 18s. 4d. The receipts, however, of 1883 and 1884 were swelled, as just stated, by the large sums paid as life compositions. The expenditure for the last three years has been reduced by careful supervision, and it is hoped that this expenditure will not be much exceeded for some time to come. The Council, however, feel the necessity of urging the Fellows to use their best efforts in adding to their number.

The Meteorological Council have made the usual annual grant of £25 towards the expenses incurred in the Inspection of Stations, as well as the ordinary payments for copies of the Weekly, Monthly and Annual Returns from the Society's Stations, all of which are shown in the Balance Sheet.

APPENDIX I.

REPORT ON THE INSPECTION OF THE STATIONS DURING 1886.

The stations in the South-west of England and Wales, as well as those at Addiscombe, Beddington, Lincoln, Marlborough, and Wakefield, have been inspected during the year, and found to be, with some few exceptions, generally in a satisfactory condition. Since the previous inspection there has been a change of observer or deputy observer (owing to removal or death) at several of the stations, and an examination of the instruments as well as some instruction in the methods of observing was greatly needed.

At one station, Llandudno, which had not been visited for three years, the trees had been allowed to grow to such an extent that it was necessary to recommend that the observations be forthwith taken from instruments placed in a more satisfactory situation.

At some of the other stations it was also necessary to request the observers to keep the shrubs and trees cut back, so as to ensure free exposure for the instruments.

The number of thermometers tested has been 159. Several changes have taken place in the zeros of the instruments, chiefly in those with comparatively new tubes.

Photographs have been taken of the Welsh and the new stations. Prints of these have been mounted in the Album, which now contains photographs of all the stations of the Society inspected during the past three years.

William Marriott,
October 5th, 1886. Assistant-Secretary.

NOTES ON THE STATIONS.

Addiscombe, *May 27th*.—At the end of December 1885 Mr. Mawley removed the greater part of his instruments to Berkhamsted, when the second order observations were discontinued. He, however, left sufficient instruments for a Climatological Station, and since January 1st, 1886, observations have been taken regularly at 9 a.m. The station was in a satisfactory condition.

Ashburton, *August 19th*.—On comparing the thermometers it was found that the zero of the maximum had risen 0°·2. The wet bulb was not working properly as the muslin projected too far above the bulb, the upper part being dry, and an open sauce cup was used for the water receptacle. The screen also required painting.

Babbacombe, *August 20th*.—This station was in good order. The tree on the North-east side of the garden required cutting, as it made a large angle with the rain-gauge.

Beddington, *May 27th*.—All the instruments were in good order.

Boston, *June 21st*.—The observations at this station were discontinued on April 30th. The electrical thermometer and the other instruments were taken down on June 21st, and removed to Lincoln for the experimental observations to be carried out on the great tower of the cathedral.

Brampford Speke, *August 18th*.—The instruments were in the same position as at the last inspection. As the trees to the north of the rain-gauge subtended a very large angle, it was recommended that another rain-gauge should be placed in the garden in an open situation. The thermometer screen required painting.

Bude, *August 24th*.—No change appeared to have taken place in the instruments. The wet bulb was not working properly, the conducting thread being single and the water receptacle being too low. These defects were rectified before I left.

Burghill, *September 2nd*.—On comparing the thermometers it was found that the zeros of the dry bulb had risen 0°·1, the maximum 0°·1, and the minimum 0°·5. The rain-gauges had been moved to the positions selected for them at the last inspection. The shrubs, however, are growing rapidly and require to be kept cut down.

Cardiff, *August 31st*.—The instruments were moved from No. 4 to No. 15 Park Place about two years ago. The garden is small, but the situation is a slight improvement on the former place. Mr. Adams died on August 17th, and the observations will be discontinued on September 1st. I learnt, however, that the Museum authorities contemplated purchasing Mr. Adams' instruments and carrying on the observations. I called on Mr. Storrie, and found that this was the case. It was proposed to put the instruments in a field belonging to Bute Castle, where the exposure would be very good. [I have subsequently learnt that the instruments have been removed to another part of the town where the exposure is such as not to comply with the requirements of the Society.]

Carmarthen, *August 31st.*—Dr. Hearder was away from home at the time of my visit, but the Assistant Medical Officer was in charge of the observations. The muslin on the wet bulb had not been put on properly and was not working satisfactorily. On comparing the thermometers it was found that the dry bulb had risen 0°·1, and the wet 0°·3. The grass minimum had 3°·7 of spirit at the top of the tube.

Chester, *September 3rd.*—The thermometers were all in good order. A rearrangement of the thermometers in the screen was recommended, in order that they might be in a better light and more conveniently placed for reading.

Churchstoke, *September 3rd.*—All the thermometers were in good order except the grass minimum, which had 1°·4 of spirit at the top of the tube. The screen required repairing and painting. It was recommended that the sunshine recorder should be placed on the tower where there would be a free exposure, as it is probable that in its present position the trees on the East and West-north-west obstruct the sun's rays in the early morning and late evening.

Cullompton, *August 18th.*—It was recommended that the thermometer screen be moved 4 feet further West, so as to be clear of the rain-gauge. Also that the sunshine recorder be removed to a more open spot, and raised, if possible, about 20 feet above the ground, so as to be free of some trees on the west horizon.

Exeter, *August 21st.*—The Rev. P. H. Newnham (late of Maker) having recently been appointed Chaplain to the Devon and Exeter Hospital, obtained permission from the Committee to equip a Climatological Station in the grounds of the Hospital, the Committee undertaking to rail off the enclosure. I visited the Hospital on the above date and selected a site. In conversation with the House Surgeon, I learnt that Dr. Domville had a set of instruments which he was willing to present to the Hospital. I called on Dr. Domville, and found that the instruments had been presented to him by the Sanitary Institute for services rendered during the Sanitary Congress at Exeter in 1879. As his garden was too small for a satisfactory exposure, he at once gave instructions for the instruments to be transferred to the Hospital, where they were fixed up and put in position under my direction on Monday, August 23rd.

Falmouth, *August 26th.*—The instruments were removed from Mr. Fox's garden on December 31st, 1885, and placed on the lawn in front of the new Falmouth Observatory, where the exposure is very good and open. The observations are now under the charge of Mr. Kitto, Superintendent of the Observatory. On comparing the thermometers it was found that the zeros of the dry and wet had each risen 0°·1.

Ilfracombe, *August 23rd.*—The alterations suggested at the last inspection have been carried out. The flag-staff near the rain-gauge is only put up for about two months in the year. The thermometers were in good order.

Isleworth, *August 6th.*—This station was in a satisfactory condition and the instruments in good order. [Miss Ormerod was reluctantly compelled to discontinue the Climatological observations on September 30th, 1886.]

Lincoln, *June 23rd.*—By permission of the Dean and Chapter, the Electrical Thermometer which was removed from Boston Church Tower was fixed to the North-west side of the South-east pinnacle of the great Tower of Lincoln Cathedral, the cable being brought down a staircase and connected with the galvanometer in one of the vestries. A set of instruments was also placed in Mr. Mantle's garden, a short distance from the Cathedral, where a complete set of Second Order observations will be made. The whole of the observations, both in the garden and at the Cathedral, are under the charge of Mr. Mantle.

Llandudno, *September 4th.*—The lawn in front of the house on which the instruments were placed was very much overgrown with trees, in fact a bough hung immediately over the rain-gauge. The exposure of the instruments being so unsatisfactory, it was recommended that the observations be forthwith taken from another set of instruments placed in a garden on the other side of the road, where the exposure was much more satisfactory. The thermometers were found to be in good order.

Marlborough, *July 23rd.*—The Rev. T. A. Preston having removed to Thurcaston at the end of last year, the observations taken by him since 1865 were discontinued on December 31st. The College authorities subsequently decided to reorganise the meteorological station, Mr. Preston handing over some of his instruments to them for this purpose. The instruments are placed in the kitchen garden of the College, in an open situation. The sunshine recorder is placed on the roof of one of the College buildings. The observations are under the charge of Mr. Hewitt.

Princetown, *August 27th.*—The barometer has been moved from the Medical Officer's room to the lobby of Dr. Stone's house. The thermometers were in good order. It was found that the maximum and minimum thermometers had been set at 9 a.m. and 9 p.m., but the readings at 9 p.m. only had been entered. In future they will be read and set once daily, viz. at 9 p.m.

Ross, *September 1st.*—There was no change in the zeros of the thermometers. The muslin on the wet bulb was too baggy, and did not appear to be working properly. The trees and shrubs in the garden having grown up considerably, it was recommended that some of them be removed, and that the screen be shifted a little to the north, so as to be in a more open situation. The screen will also be fixed on four posts instead of on a table as at present.

Rousdon, *August 17th.*—This station is on high ground (524 feet above sea-level) about half a mile from the sea, and midway between the towns of Lyme Regis and Seaton. The instruments are placed in a kitchen garden in an open situation, but a number of shrubs and trees are planted round, which may soon grow up and shelter the instruments. All the thermometers were in a satisfactory condition except the minimum, which had 1°·2 of spirit at the top of the tube. The position of the thermometers in the screen was altered, and it was recommended that grass be laid down round the screen. In addition to a large number of meteorological instruments, including a Kew anemometer, which is mounted on the top of the water tower, Mr. Peek has two evaporation gauges,—one containing water and the other soil. The former is measured once a month, and the latter is weighed daily.

SIDMOUTH, *April 17th.*—All the instruments were in good order.

STOWELL, *August 16th.*—All the instruments were in good order. The thermometers were all correct except the minimum, which read 0°·4 too low, apparently due to some spirit at the top of the tube.

TEIGNMOUTH (BITTON), *August 20th.*—On comparing the thermometer it was found that the dry bulb had risen 0°·2. The rain-gauge is placed in a garden, close to the mouth of the river, in a well-exposed situation.

TEIGNMOUTH (WOODWAY), *August 20th.*—No change had taken place in the instruments. [Mr. Ormerod was obliged, on account of failing health, to discontinue the observations on December 31st.]

TORQUAY, *August 20th.*—Mr. Harland was away from home at the time of my visit, but the gardener was in charge of the observations. No change appeared to have taken place in the thermometers. The screen required painting.

WAKEFIELD, *June 25th.*—Owing to the serious illness of Warder Brown, who had been in charge of the observations for many years past, this station was not in such a satisfactory condition as could have been wished. After examining the instruments, the three warders who take the observations were severally instructed in the use of the instruments and in the method of taking the observations.

WESTON-SUPER-MARE, *August 30th.*—All the thermometers were correct except the minimum, which had some spirit at the top of the tube. As the screen was not very firmly fixed, it was recommended that additional supports be provided. The screen also required painting.

APPENDIX II.

OBITUARY NOTICES.

PROFESSOR GEORGE T. KINGSTON was born near Oporto, Portugal, where his father, who was an English merchant, was residing. When a boy he went into the Navy, but he found that a seafaring life was not suitable to his constitution, and he left the service and entered himself as a student in Gonville and Caius College, Cambridge.

From Cambridge he graduated with mathematical honours, taking a position among the Wranglers. Having spent some years in teaching, he went to Canada to take charge of the Naval School at Quebec. On the abolition of that School, he was appointed, in August 1855, Director of the Toronto Observatory, and Professor of Meteorology in the University of Toronto.

In 1871, the Meteorological Service of Canada was established, and Prof. Kingston was appointed Superintendent, an honour which was due to him not only on account of his knowledge and experience, but also because he had taken an active part in having the Service established.

He retained all his positions until early in 1880, when he resigned. He afterwards went to England to visit his brother, Mr. W. H. G. Kingston, the celebrated author of boys' books, and found on his arrival that he was only in time to see his brother before he died.

Professor Kingston's natural tastes would never have led him to the study of Meteorology, what he would have liked would have been to engage himself as a Professor in teaching Mathematics, but his position as Director of the Observatory in Toronto was in a measure forced upon him, and in it he did the best he could. The only thing worthy of particular note that he introduced into Canada in the way of observing was the Thermometer Screen, which he had constructed at Toronto, and supplied to the various observing stations all over the country, and which was almost identical with the screen subsequently designed by Dr. Wild of St. Petersburg.

Professor Kingston was elected an Honorary Member of the Royal Meteorological Society on June 17th, 1874.

He died at Toronto on January 21st, 1886.

Robert James Mann was born in Norwich in January 1817. At an early age he evinced a great love of, and aptitude for, physical science. Botany was his first pursuit, and, while still a student, he published an excellent list of the flowering plants of the Norfolk district.

He was educated for the medical profession, and studied at University College. He took the M.R.C.S. and L.S.A. degrees in 1840, and for some time practised in Norfolk, continuing his scientific pursuits, and beginning to occupy himself with literary undertakings also. It was during this time that he published his first book, *The Planetary and Stellar Universe.*

In 1853 domestic circumstances, connected with health, caused him partially to abandon the practice of his profession. In 1854 he became an M.D. of St. Andrew's, and about this time was employed in assisting his old teacher and attached friend, Dr. C. J. B. Williams, in the revision and publication of his *Principles of Medicine*, assistance the value of which was generously acknowledged in the work itself, and again in the much more recently published *Memorials of Life and Work* of that eminent physician.

In 1857, on the invitation of Bishop Colenso, Dr. Mann left England for Natal, where he resided for nine years, during seven of which he was Superintendent of Education for that colony; an office established by the then Governor, Mr. (now Sir John) Scott, to which he received the first appointment. In this capacity he succeeded, working against great difficulties, in starting elementary schools for both the English and Dutch inhabitants, and ultimately in assisting those for the native population also. This, no doubt, is a noteworthy achievement in his life, and its value and the way in which it was accomplished have since his death been borne testimony to in the *Natal Mercury* of September 14th, 1886, in the following words:—"For several years he gave up his time most unsparingly to a task which to him was a labour of love, and the measure of his personal success may be gauged by the extent to which his work suffered when his own part in it was withdrawn."

From his first arrival in Natal he also carried out day by day and recorded meteorological observations, the results of which he communicated in various papers to the Royal Meteorological Society. While in Natal he was the referee of the whole colony on all matters connected with science.

In 1862 he was the chief organiser of the exhibits the Colony contributed to the Great Exhibition of that year, and he arranged and carried out a preliminary Exhibition in Durban.

He returned from Natal in 1866, in consequence of receiving a special appointment from the Legislative Council to inaugurate a scheme of Government emigration to the Colony. This he held for four years, during which, besides undertaking all the arduous work of his official position, he took charge of the arrangements of the Natal exhibits in the Paris Exhibition of 1867. He laboured gratuitously in promoting emigration to Natal for two years after his appointment as agent was withdrawn.

From about that time he ceased to have any special connection with the Colony, and for the rest of his life devoted himself to the scientific and literary pursuits which had ever been congenial and delightful to him.

Of all the sciences which early engaged his attention and became subjects of study none excited so profound an interest or kept so permanent a hold upon his regard as that of astronomy. All through his life it was the one which he would have desired, had circumstances permitted, to make his chief pursuit and occupation. He was the author of several works on Astronomical subjects.

Dr. Mann was for many years on the staff of the *Edinburgh Review*, and the admirable articles which he contributed to it on astronomical subjects are well known. His last piece of literary work, indeed, was an article on "The Recent Progress of Astronomy," which appeared in the number for April 1886. He was a popular and prolific writer, and was a frequent contributor to several magazines and reviews. The protection of buildings from lightning was a subject on which he wrote a good deal, and for which he did much valuable work.

In 1874 he was appointed Secretary to the African Section of the Society of Arts; a post he only resigned in consequence of failing health a few months before his death. For four years he served as one of the Board of Visitors of the Royal Institution, of which he became a Member in 1876, subsequently being elected on the Council. In 1878 he was elected a Fellow of the Royal College of Surgeons.

Dr. Mann was well known in scientific circles, and for many years he was a member of the Astronomical, Geographical, and Photographic Societies.

He served on the Council of the Royal Meteorological Society from 1868 to 1878, and was President 1873-76.

From first to last he was a most active and indefatigable worker, and his end was probably hastened by the fact that during the last four months of his life, when already in failing health, he was busily engaged in preparing and bringing out the Catalogue of the Natal Court at the Colonial and Indian Exhibition. He was in the Natal Court working at this Catalogue only three days before he was suddenly struck down by paralysis, which terminated fatally two days afterwards, on August 4th. He was buried at Kensal Green Cemetery.

Mr. A. **Henry Taylor** became a Fellow of the Royal Meteorological Society on May 19th, 1880.

Having never been engaged in any profession or business, he had ample leisure, and he spent much of it in observing the weather and in entomology. In the latter line of study he had formed a considerable collection of British Lepidoptera, chiefly caught or bred by himself. His very benevolent disposition led him not only to devote a good deal of his income to charity, but to spend much time and trouble in the management of provident clubs and similar undertakings for the benefit of the poor.

About twelve years ago he started an Observatory of the Second Order in Folkestone, and for several years sent to the Meteorological Office his monthly sheet of observations, very accurately taken and recorded. Soon after commencing this work, and before the Meteorological Office had begun to issue forecasts, he undertook the preparation of daily forecasts of the weather for Folkestone, which were posted up every morning at the Radnor Club in that town. These were continued for some years, and were much valued; and persons proposing to make excursions would every now and then send to him to know what the weather was going to be. On ceasing to supply these daily local presages of the weather, he was presented by the Club with a handsome Star Atlas in acknowledgment of his "valuable and accurate forecasts," the Secretary stating that they must have been right at least six times out of seven, and in his opinion decidedly oftener.

Attacked in the summer of 1884 by a very serious disease, he rarely left his room or his bed afterwards; but he continued to the last to take undiminished interest in the weather and in general topics. During the whole of his long illness, his indomitable "pluck" and good spirits, and his kindly and genial cheerfulness and forgetfulness of self, were the admiration of all who knew him, whilst he contemplated death with a somewhat philosophic calmness, which a clergyman of considerable experience, who saw much of him, has never known equalled. He quietly passed away on 23rd July, 1886, at the age of 56 years.

APPEN-

ABSTRACT OF RECEIPTS AND EXPENDITURE

RECEIPTS.

	£	*s.*	*d.*	£	*s.*	*d.*
Balance from 1885				155	7	3
Dividend—M. S. and L. R. 4½ Debenture Stock, £800....	34	16	0			
Do. N. S. W. Stock, 4½ per Cent. £500	19	6	8			
Do. New 3 per Cents., £250	5	16	0			
				59	18	8
Subscriptions for 1882	2	1	0			
Do. 1883	2	1	0			
Do. 1884	7	2	0			
Do. 1885	18	4	0			
Do. 1886	613	7	0			
Do. 1887	30	4	0			
Do. 1888	2	0	0			
Life Composition (old rate)............................	12	0	0			
Do. Additional (Mr. W. M. Beaufort)	9	0	0			
Entrance Fees	18	0	0			
				713	19	0
Meteorological Office:—						
Copies of Weekly Returns	4	16	4			
Do. Monthly „	103	11	0			
Do. Annual „	2	10	0			
Grant towards Inspection Expenses	25	0	0			
				135	17	4
Sale of Publications				43	13	11
				£1108	16	2

DIX III.

FOR THE YEAR ENDING DECEMBER 31st, 1886.

Expenditure.

	£	s.	d.	£	s.	d.
Journal, &c.:—						
Printing Nos. 57-60	142	5	6			
Illustrations	21	10	0			
Authors' Copies	15	1	0			
Meteorological Record, Nos. 19-22	53	12	0			
Registrar-General's Reports	8	8	0			
				240	16	6
Printing, &c.:—						
General Printing	18	13	0			
List of Fellows	11	11	0			
Forms for Observations	14	19	0			
Stationery	5	16	11			
Books and Bookbinding	20	16	11			
				71	16	10
Salaries:—						
Assistant-Secretary	180	0	0			
Computers	166	8	0			
				346	8	0
Office Expenses:—						
Rent and Housekeeper	48	9	0			
Furniture and Repairs	21	7	0			
Coals, Insurance, &c.	3	13	6			
Postage	44	0	11			
Parcels and Petty Expenses	6	17	1			
Refreshments at Meetings	13	9	0			
Barometer Exhibition Expenses	5	4	6			
Subscriptions overpaid returned	4	0	0			
				147	1	0
Observations:—						
Inspection of Stations	36	13	11			
Photography	3	7	1			
Observers at Boston, Old Street and Seathwaite	10	11	0			
Instruments	4	4	0			
				54	16	0
				860	18	4
Balance:—						
At Bank of England	237	14	9			
In hands of the Assistant-Secretary	10	3	1			
				247	17	10
				£1108	16	2

Examined and compared with Vouchers, and found correct,

F. C. BAYARD,
R. STRACHAN, } *Auditors.*

January 10*th*, 1887.

APPENDIX III.—Continued.

ABSTRACT OF ASSETS AND LIABILITIES ON JANUARY 1st, 1887.

Liabilities.	£	s.	d.
To Subscriptions for 1887 and 1888 paid in advance	32	4	0
,, Excess[1] of Assets over Liabilities	2207	5	4
	£2239	9	4

Assets.	£	s.	d.	£	s.	d.
By Investment in M. S. and L. R. 4½ Debenture Stock, £800 at 129	1032	0	0			
,, Investment in N. S. W. Stock 4 per Cent. £500 at 107¼	536	5	0			
,, ,, New 3 per Cents. £200 at 101¼	202	10	0			
				1770	15	0
,, Subscriptions unpaid, estimated at	60	0	0			
,, Entrance Fees unpaid..........................	4	0	0			
,, Dividend—M. S. and L. R. 4½ Debenture Stock, £800	17	8	0			
,, ,, N. S. W. Stock, 4 per Cent. £500	9	13	4			
,, Meteorological Office—Weekly Returns, 1886	4	15	2			
				95	16	6
,, Furniture, Fittings, &c.	45	0	0			
,, Instruments	80	0	0			
				125	0	0
,, Cash in hands of Bank of England	237	14	9			
,, ,, the Assistant-Secretary..	10	3	1			
				247	17	10
				£2239	9	4

F. C. BAYARD, } *Auditors.*
R. STRACHAN, }
WILLIAM MARRIOTT, *Assistant-Secretary.*

January 10*th*, 1887.

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[1] This excess is exclusive of the value of the Library and Stock of Publications.

APPENDIX IV.

LIST OF BOOKS PURCHASED.

Bebber, Dr. W. J. van.—Handbuch der ausübenden Witterungskunde. Geschichte und gegenwärtiger Zustand der Wetterprognose. Zwei Theile. 8vo. (1885-6).

Chiswick.—Journal of Meteorological Observations made at the Garden of the Horticultural Society, 1825-38 and 1841-44. 4to. (1826-45.)

Criswick, H. C.—The Agriculturist's Weather Guide and Manual of Meteorology. 8vo. (1863.)

Encyclopædia Britannica. Ninth Edition. Vols. XX. and XXI. 4to. (1886.)

L'Institut Meteorologique Danois et le Deutsche Seewarte.—Cartes Synoptiques Journalières du Temps, embrassant le Nord de l'Atlantique, March to August 1882. Folio. (1885.)

L'Observatoire Physique Central de Russie.—Annales, 1847 and 1848. 4to. (1850-1.)

London.—Fifth Annual Report of the Registrar-General. Second Edition. 8vo. (1843.)

Scott, R. H.—Manuel Barométrique. Traduit par MM. Zurcher et Margollé. 8vo. (1870.)

Sopwith, T.—An Account of the Mining Districts of Alston Moor, Weardale, and Teesdale. 12mo. (1833.)

The "Times" Register of Events in 1885. 8vo. (1886.)

Walferdin, M.—Modifications au Thermomètre Horizontal à Minimum, de Rutherford. 4to. (1855.)

Walferdin, M.—Thermomètre à Maximum à bulle d'air. 4to. (1855.)

Whistlecraft, O.—Variations of Seasons in the Eastern parts of England, as observed at Thwaite, Suffolk, 1811-82. 8vo. (1887.)

Year Book of the Scientific and Learned Societies of Great Britain and Ireland, 1886. 8vo. (1886.)

APPENDIX V.

DONATIONS RECEIVED DURING THE YEAR 1886.

Presented by Societies, Institutions, &c.

Adelaide, Meteorological Society of Australasia.—History, Rules and Regulations, List of Members.

Adelaide, Royal Society of South Australia.—Transactions and Proceedings and Report, Vol. VIII. 1884-5.

Berlin, Deutsche Meteorologische Gesellschaft.—Berliner Zweigverein, 1886.—Meteorologische Zeitschrift, Dec. 1885 to Dec. 1886.

Bombay, Government Observatory, Colába.—Annual Statement of Rainfall in the North-western Provinces and Oudh for the year 1885.—Magnetical and Meteorological Observations, 1884.

Bombay, Meteorological Office.—Brief Sketch of the Meteorology of the Bombay Presidency in 1883-4, and 1884-5.

Brisbane, General Register Office.—Report of the Registrar-General on Vital Statistics, 1885.--Report on the Vital Statistics, Oct. 1885 to Oct. 1886.

Brussels, Institut National de Géographie.—Bulletin Météorologique, Dec. 1885 to Nov. 1886.

Brussels, Observatoire Royal.—Annuaire, 1886.

Buckhurst Hill, Essex Field Club.—Report on the East Anglian Earthquake of April 22nd, 1884. By Prof. R. Meldola and W. White.

Budapest, Kön. Ung. Central-anstalt für Meteorologie und Erdmagnetismus.—Jahrbuch, 1880-84.

Bukharest, Institutul Meteorological Romaniei.—Annales, Tome I. 1885.—Buletinul Ministerului Agriculturei, Industriei, Comerciului si Domeniilor, 1885, Nos. 8 to

12.—Istoricul Studiilor Meteorologice in Romania. De St. C. Hepites.—Observatiuni Meteorologice facute la Bucuresci in anul 1885.

Cairo, Ministère de l'Instruction Publique.—Resumé Mensuel des Observations Météorologiques faites à l'Observatoire Khedivial du Caire (Abbassieh), Oct. 1885 to Sept. 1886.

Cairo, Société Khédiviale de Géographie.—Bulletin, IIe. Série, Nos. 8 and 9.

Calcutta, Meteorological Office.—Indian Meteorological Memoirs, Vol. II. Part 5, Vol III. Part 1, and Vol. IV. Part 1.—Registers of Original Observations, reduced and corrected, June 1885 to June 1886.—Report on the Administration of the Meteorological Department of the Government of India in 1884-85.—Report on the Meteorology of India in 1884.

Calcutta, St. Xavier's College Observatory.—Meteorological Observations, July to Dec. 1885.

Cambridge, Mass., New England Meteorological Society.—Bulletin, Nos. 14 to 24.

Cape Town, Meteorological Commission.—Report for 1885.

Cape Town, South African Philosophical Society.—Transactions, Vol. III. Part 2.

Christiania, Editing Committee, Norwegian North Atlantic Expedition 1876-1878.—Zoology. Crustacea, II. By G. O. Sars.—Mollusca, II. By A. Friele.

Christiania, Norwegisches Meteorologisches Institut.—Jahrbuch 1885.

Copenhagen, Danske Meteorologiske Institut.—Annuaire Météorologique, 1883, Part 2; 1884, Parts 1 and 3.—Bulletin Météorologique du Nord, Dec. 1885 to Nov. 1886.

Cordoba, Academia Nacional de Ciencias.—Boletin, Tomo VIII. Parts 1 to 4.

Cracow, K. K. Sternwarte.—Meteorologische Beobachtungen, Nov. 1885 to Oct. 1886.

Dorpat, Kaiserliche livlandische gemeinnützige und ökonomische Societät.—Bericht über die Ergebnisse der Beobachtungen an den Regenstationen für 1885.

Dorpat, Meteorologisches Observatorium.—Ueber die Berechnung meteorologischer Jahresmittel. Von Prof. Dr. K. Weihrauch.

Dublin, General Register Office.—Twenty-second Detailed Annual Report of the Registrar-General of Ireland, 1885.—Weekly Returns of Births and Deaths, Vol. XXII. No. 52 to Vol XXIII. No. 51.

Dublin, Royal Dublin Society.—Scientific Proceedings, Vol. IV. (New Series) Part 7 to Vol. V. Part 2.—Scientific Transactions, Vol. III. (Series II.), Parts 7 to 10.

Edinburgh, General Register Office.—Quarterly Returns of the Births, Deaths and Marriages registered in Scotland, for the four quarters ending Sept. 30, 1886.—Supplement to the Monthly and Quarterly Returns of the Births, Deaths and Marriages registered in Scotland during the year 1885.

Edinburgh, Royal Society.—Proceedings, Nos. 85 to 86.

Edinburgh, Scottish Geographical Society.—Scottish Geographical Magazine, Jan. 1885 to Dec. 1886.

Fiume, I. R. Accademia di Marina.—Meteorological Observations, Nov. 1885 to Oct. 1886.

Geneva, Société de Géographie.—Le Globe, Bulletin, 4me Serie, Tome V. Nos. 1 and 2.

Glasgow, Philosophical Society.—Proceedings, Vol. XVII. 1885-6.

Greenwich, Royal Observatory.—Diagrams representing the Diurnal Change in Magnitude and Direction of the Magnetic Forces in the Horizontal Plane, 1841-1876. By Sir G. B. Airy.—Report of the Astronomer Royal to the Board of Visitors, June 5, 1886.—Results of the Magnetical and Meteorological Observations, 1884.

Hamburg, Deutsche Seewarte.—Aus dem Archiv, 1884.—Meteorologische Beobachtungen in Deutschland, 1883.—Monatliche Uebersicht der Witterung, March to Dec. 1885.—Wetterbericht, 1886.

Helsingfors, Société des Sciences de Finlande.—Beobachtungen über die periodischen Erscheinungen des Pflanzenlebens in Finnland 1883, zusammengestellt von Dr. A. O. Kihlman.—Exploration Internationale des Régions Polaires. Observations faites aux Stations de Sodankylä et de Kultala.

Hongkong, Observatory.—Annual Weather Report of the Director for 1885.—Magnetic Observations made during 1885.—Observations and Researches during 1885, by Dr. W. Doberck.—On one year's observations of Thermometers exposed in Stevenson's Screen.—Report of the Director for the year 1885.—Report of the Director on Five day Means of the principal Meteorological Elements for 1885.—Report on Information issued daily, in 1885, concerning Typhoons.—Report on the Typhoons of 1884 and 1885.—Results of Barometric Observations made during 25 years in Hongkong.—Results of Magnetic Observations, 1841-1885.—Verification of the Unifilar Magnetometer.—Weather Report, Oct. 1885 to Sept. 1886.

Kew, Observatory.—Report of the Kew Committee for the year ending Oct. 31, 1885.

Lisbon, Observatorio do Infante D. Luiz.—Annaes 1883 and 1884.—Postos Meteorologicos, 1879.

Lisbon, Sociedade de Geographia.—Boletim, 5a Serie, Nos. 6 to 12; 6a Serie, Nos. 1, 2, 5 and 6.—Le Congo, par G. Arthur.

Liverpool, Bidston Observatory.—Report on Arrangements made for enabling mariners to find Greenwich time at sea by chronometers.—Reports of the Astronomer to the Marine Committee, Mersey Docks and Harbour Board, 1862-5, and 1869-78.—Results of Meteorological Observations during the years 1879 to 1883.

London, British Association.—Canadian Economics.—Report, 1885.

London, Colonial and Indian Exhibition (Victorian Court).—Illustrated Handbook of Victoria, Australia.

London, Colonial Office.—Straits Settlements. Meteorological Report for 1885.

London, East India Association.—Journal, Vol. XVIII. No. 5.

London, General Register Office.—Annual Summary of Births, Deaths and Causes of Death in London and other great towns, 1885.—Quarterly Returns of Marriages, Births and Deaths for the four quarters ending Sept. 30, 1886.—Weekly Returns of Births and Deaths, Vol. XLVI. No. 52 to Vol. XLVII. No. 51.

London, Geological Society.—Quarterly Journal, Nos. 165 to 168.

London, Meteorological Office.—Bulletin quotidien de l'Algérie, Dec. 16, 1885, to Nov. 15, 1886.—Charts showing the Mean Monthly and Annual Temperatures of Hudson's Bay Region and Eastern Canada, Sept. 1884 to Oct. 1885. By A. R. Gordon.—Daily Weather Reports, 1886.—Fifty-third Annual Report of the Royal Cornwall Polytechnic Society, 1885.—Geschiedkundig Onderzoek der Nederlandsch Aardrijkskundige Namen. I. ste Deel.—Hourly Readings, July to Sept. 1883, and Jan. to March 1884.—Indian Daily Weather Reports, July 1, 1883, to June 30, 1886.—Meteorological Observations at Stations of the Second Order, 1881.—Meteorological Observations made at Southport, Dec. 5, 1885, to July 9, 1886.—Monthly Weather Report, Sept. 1885 to June 1886.—Observations of the International Polar Expeditions, 1882-83, Fort Rae.—Papers and Proceedings of the Royal Society of Tasmania, 1885.—Quarterly Weather Report, New Series, 1877, Part 4, and 1878, Part 1.—Reply to Prof. Tyndall's Remarks on his work "On the Glaciers of the Alps," by J. D. Forbes, F.R.S.—Report of the Meteorological Council to the Royal Society for the year ending March 31, 1885.—Report on the Meteorology of Ceylon, 1885.—Riassunti Decadici e Mensili delle Osservazioni Meteoriche fatte nel R. Osservatorio di Capodimonte nell' anno 1883.—Service Central Météorologique de l'Algérie, Bulletin Mensuel, Nos. 5 to 17.—Statistique de la Grêle tombée en Algérie, 1876-85.—Tri-daily Weather-Maps, April 1886, issued by the Imperial Meteorological Observatory, Japan.—Weekly Weather Report, New Series, Vol. II. No. 52 to Vol. III. No. 51.—Western Australia: Meteorological Report, 1884.

London, Physical Society.—Proceedings, Vol. VII. Part 4 to Vol. VIII. Part 2.

London, Royal Agricultural Society.—Journal, Second Series, Vol. XXII.

London, Royal Astronomical Society.—Monthly Notices, Vol. XLVI. Nos. 2 to 10.

London, Royal Botanic Society.—Quarterly Record, Nos. 1 to 5 and 24 to 27.

London, Royal Institution of Great Britain.—List of Members, &c. 1885.—Proceedings, No. 79.

London, Royal Society.—Proceedings, Nos. 240 to 247.

London, Sanitary Institute of Great Britain.—Transactions. Vols. VI. and VII.

London, Society of Arts.—Journal, Nos. 1728 to 1779.

London, Society of Telegraph Engineers and of Electricians.—Journal, Nos. 59 to 63.

Madrid, Observatorio.—Resúmen de las Observaciones Meteorológicas efectuadas en la Peninsula durante el año de 1881.

Madrid, Sociedad Geografica.—Boletin, Tomo XIX. No. 5, to Tomo XXI. No. 4.

Magdeburg, Wetterwarte der Magdeburgischen Zeitung.—Das Wetter, Jan. to March and May to October 1886.—Jahrbuch, 1884. Herausgegeben von Dr. R. Assmann.

Marlborough, College Natural History Society.—Report, 1885.

Mauritius, Royal Alfred Observatory.—Mauritius Meteorological Results, 1884 and 1885.

Melbourne, Government Observatory.—Monthly Records of Results of Observations in Meteorology, Terrestrial Magnetism, etc., July 1885 to July 1886.

Metz, Académie.—Observations Météorologiques, 1881 and 1882.

Mexico, Ministerio de Fomento.—Boletin, Tomo X. Nos. 98 to 146.

Mexico, Observatorio Meteorológico-Magnético Central.—Estudios de Meteorologiá comparada por M. Bárcena y M. Pérez. Tomo I.

Michigan, State Board of Health.—Michigan Crop Report, Dec. 1885 to Dec. 1886.—Principal Meteorological Conditions in Michigan in 1883.—Proceedings and Addresses at Sanitary Conventions held at Ypsilanti, Michigan, June 30 and July 1, 1885; at Howell, Michigan, March 3 and 4, 1886; and at Kalamazoo, Michigan, June 1 and 2, 1886.—Reports of the Secretary for the years ending Sept. 30, 1884, and Sept. 30, 1885.

Milan, R. Osservatorio Astronomico di Brera.—Osservazioni Meteorologiche eseguite nell' anno 1885.

Moscow, Landwirthschaftliche Akademie.—Meteorologische Beobachtungen, July to Dec. 1885.

Moscow, Société Impériale des Naturalistes.—Bulletin, 1884, No. 4, to 1886, No. 2.

Munich, K.B. Meteorologische Central-Station.—Beobachtungen der meteorologischen Stationen im Kon. Bayern, Jahrgang VII. Heft 3 to Jahrgang VIII. Heft 3.—Uebersicht über die Witterungsverhältnisse im Kon. Bayern, Dec. 1885 to Oct. 1886.

Munich, K. Sternwarte.—Astronomisch-geodätische Bestimmungen, ausgeführt an einigen Hauptpunkten des Bayerischen Dreiecksnetzes.—Meteorologische und magnetische Beobachtungen, 1885.—Nachträge zu den Zonenbeobachtungen.

Natal, Observatory.—Report of the Superintendent for the year 1885.

Neuchatel, Société Neuchateloise de Géographie.—Bulletin, Tome I. and Tome II. Parts 1 and 2.

New York, Central Park Observatory.—Abstracts of Registers from Self-Recording Instruments, Dec. 1885 to Nov. 1886.

Oxford, Radcliffe Observatory.—Results of Meteorological Observations, 1883.

Paris, Bureau Central Météorologique de France.—Annales, 1882, Part 2; 1883, Parts 1, 3, and 4.—Bulletin International, 1886.

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Philadelphia, American Philosophical Society.—Proceedings, Nos. 121 to 123.

Pola, K. K. Hydrographisches Amt.—Meteorologische und Magnetische Beobachtungen, Dec. 1885 to Nov. 1886.

Prague, K. K. Sternwarte.—Magnetische und Meteorologische Beobachtungen, 1885.

Rio de Janeiro, Imperial Observatorio.—Revista do Observatorio, Anno I., Nos. 1 to 11.

Rome, Ufficio Centrale di Meteorologia Italiana.—Annali, Serie II., Vol. V., 1883.

St. Petersburg, Kaiserliche Academie der Wissenschaften.—Repertorium für Meteorologie, Band IX.

St. Petersburg, K. Russische Geographische Gesellschaft.—Beobachtungen der Russischen Polarstation an der Lenamundung. Meteorologische Beobachtungen vom Jahre 1882-1883.

St. Petersburg, Physikalisches Central Observatorium.—Annalen, 1884.

San Fernando, Instituto y Observatorio de Marina.—Anales. Seccion 2a. Observaciones Meteorológicas, 1885.

Santiago, Oficina Central Meteorologica de Chile.—Anuario, Tomo XVIII. 1886, Parts 1 to 3.

Stonyhurst, College Observatory.—Results of Meteorological and Magnetical Observations, 1885.

Sydney, Department of Mines.—Annual Report, 1885.

Sydney, Government Observatory.—Results of Rain and River Observations made in New South Wales during 1885.

Tokio, Imperial Meteorological Observatory.—Monthly and Yearly Means, Extremes and Sums for the years 1883 to 1885.—Monthly Summaries and Monthly Means for the year 1885, with 42 Maps.—Report of the Meteorological Observations for the ten years 1876-85.—Report of the Meteorological Observations in the Empire of Japan for Jan. to May 1883.—Tokio Meteorological Report for 1885, prepared from tri-hourly observations.

Toronto, Magnetical Observatory.—General Meteorological Register for the year 1885.

Toronto, Meteorological Office.—Monthly Weather Review, Dec. 1885 to Oct. 1886.—Report of the Meteorological Service of the Dominion of Canada, 1883.

Trieste, K. K. Handels-und Nautische Akademie.—Rapporto Annuale dell' Osservatorio Marittimo di Trieste, 1884.

Turin, Società Meteorologica Italiana.—Annuario Meteorologico Italiano, Anno I. 1886.—Bollettino Decadico pubblicato per cura dell' Osservatorio Centrale del Real Collegio Carlo Alberto in Moncalieri, April to Nov. 1885.—Bollettino Mensuale pubblicato per cura dell' Osservatorio Centrale del Real Collegio Carlo Alberto in Moncalieri, Serie II. Vol. V. No. 9, to Vol. VI. No. 10.—Le Osservazioni Meteorologiche eseguite da Giacomo Bove nel territorio Argentino delle Missioni ed il Clima del Paranà. Del P. F. Denza.

Upsala, Observatoire de l'Université.—Bulletin Météorologique Mensuel, Jan. to Dec. 1885.

Utrecht, K. Nederlandsch Meteorologisch Instituut.—Meteorologisch Jaarboek, 1885.

Vienna, Kaiserliche Akademie der Wissenschaften.—Die Österreichische Polarstation Jan Mayen. Beobachtungs-Ergebnisse herausgegeben von der K. Akademie der Wissenschaften. Band I., Band II. Part I. and Band III.

Vienna, K. K. Centranstalt für Meteorologie und Erdmagnetismus.—Beobachtungen, Nov. 1885 to Sept. 1886.—Jahrbuch, 1884.

Vienna, Oesterreichische Gesellschaft für Meteorologie.—Meteorologische Zeitschrift, Dec. 1885 to Dec. 1886.

Washington, Smithsonian Institution.—Report, 1884.

Washington, U.S. Geological Survey.—Annual Reports, 1881-82 and 1883-4.

Washington, U.S. Signal Office.—Monthly Weather Review, Oct. 1885 to Jan. 1886. —Report of the International Polar Expedition to Point Barrow, Alaska.—Thermometer Exposure. By H. A. Hazen.—Tornado Studies in 1884. By Lieut. J. P. Finley.

Watford, Hertfordshire Natural History Society.—Catalogue of the Library.—Transactions, Vol. III. Part 7, to Vol. IV. Part 3.

Wellington College, Natural Science Society.—Report, 1885.

Wellington, Registrar-General's Office.—Statistics of the Colony of New Zealand for the year 1884.

Wisconsin, University.—Agricultural Experiment Station; Bulletin, Nos. 8 to 10.—Report of the Agricultural Experiment Station, 1885.

Zi-Ka-Wei, Observatoire Magnétique et Météorologique.—Bulletin Mensuel, Feb. to May, 1885.—L'Inclinaison des Vents. Un Anémomètre pour observer cette inclinaison. Par P. M. Dechevrens.

Zürich, Schweizerische Meteorologische Central-Anstalt.—Annalen, 1884.—Schweizerische meteorologische Beobachtungen, Supplementband: Part 6.

Presented by Individuals.

Angström, K.—Sur une Nouvelle Méthode de faire des Mesures absolues de la Chaleur rayonnante ainsi qu'un Instrument pour enregistrer la Radiation solaire.

Augustin, Dr. F.—Ueber die jährliche Periode der Richtung des Windes.

Baker, Dr. H. B.—Notes on the Relations of Rainfall and Water-supply to Cholera. —The Causation of Pneumonia.

Bell, Dr. R.—The Forests of Canada.

Benn, T. G.—Remarks on the Weather and Crops, from Observations taken at the Newton Reigny Observatory, Penrith, Dec. 1883 to Dec. 1885.

Binyon, J. B.—Rainfall, etc. at Blackrock, near Cork, Dec. 1885 to Nov. 1886. (MS.)

Blanford, H. F., F.R.S.—Memorandum to accompany Charts of Temperature and Rainfall of India. Exhibited at the Colonial Exhibition, 1886.

Buchan, A.—The Rainfall of the British Islands.

Bund, J. Willis.—Tables and Diagrams showing Rainfall, Temperature and Height of the Rivers in the Severn Fishery District in 1885.

Cameron, Dr. J. S.—Annual Report of the Medical Officer of Health of the Borough of Huddersfield, 1885.

Capron, J. Rand.—A Plea for the Rainband, and the Rainband vindicated.

Carlier, A.—Observations Météorologiques faites à Observatoire de Saint Martin-de-Hinx, France (Landes), Dec. 1, 1884, to Nov. 30, 1885.

Castro-Lopes, Dr. A. de.—Le Soleil, comment se forme sa lumière ce qu'elle est l'Ether, Taches et Eruptions solaires.

Chambers, F.—Variations of the Prices of Staple Food Grains in the Bombay Presidency.

Clark, J. E.—The Natural History Journal and School Reporter, Nos. 82 to 90.

Cloué, Vice-Amiral G.—L'Ouragan de Juin 1885 dans le Golfe d'Aden.

Coventry, F.—Meteorological Observations taken at Ketton Hall, near Stamford, Rutland, Dec. 27, 1885, to Dec. 25, 1886. (MS.)

Doberck, Dr. W.—The Law of Storms in the Eastern Seas.

Doering, O.—Observaciones Meteorológicas practicadas en Córdoba (República Argentina) durante el año de 1884.—Resultados de Algunas Mediciones Barométricas en la Sierra de Córdoba.—Variabilidad de la Temperatura de Ushuaia.

Draper, D.—Memoir of John William Draper, 1811-1882. By G. F. Barker.

Eaton, H. S.—Report on the Temperature and Rainfall of the Croydon District, 1881-85.

Edmonds, F. B.—The Land's End District. By R. Edmonds.

Erk, Dr. F.—Der Föhnstürm vom 15 und 16 Oktober 1885 und seine Wirkungen im bayerischen Gebirge.

FitzGerald, D.—Evaporation.

Fox, W. L.—Tables of Sea Temperature, Bright Sunshine and Climate at Falmouth for the year 1885.

Gibson, W. M.—Rush's Balloon Ascents.

Glyde, E. E.—Abstract of Meteorological Observations made at Babbacombe, Torquay, during 1885.—Meteorological Summaries for Babbacombe, Nov. 1885 to Oct. 1886.

Greenwood, W. N.—Kludonometric Tide Tables for Glasson Dock, Lancaster, Fleetwood and Liverpool, 1887.

Hall, M.—Jamaica Weather Report, Nov. 1885 to April 1886.

Hamberg, Dr. H. E.—De l'Influence des Forêts sur le Climat de la Suède, I. and II.

Hann, Dr. J.—Beiträge zur Kenntniss der Vertheilung des Luftdruckes auf der Erdoberfläche—Bemerkungen zur täglichen Oscillation des Barometers.—Gewitterperioden in Wien.

Harvey, Rev. C. W.—Rainfall in Herts, Dec. 1885 to Sept. 1886.

Hazen, H. A.—The Condensing Hygrometer and the Psychrometer.

Hellmann, Dr. G.—Ueber die tägliche Periode der Gewitter in Mitteleuropa und einige damit-im-zusammenhange-stehende Erscheinungen.

Hoffmann, Prof. H.—Beobachtungen über thermische Vegetations-Constanten.—Phænologische Studien über den Winterroggen, Secale cereale hybernum.

Hunter, J.—Meteorological Observations at Belper, 1886.

Jackson, W. E.—Meteorological Observations taken at Erenkeuy, Constantinople, Dec. 21, 1885, to Nov. 30, 1886. (MS.)

Jough, J. J. de.—Monthly Results of Meteorological Observations made at San José, Costa Rica, Nov. 1885. (MS.)

Kammermann, A.—Le Thermomètre à Boule Mouillée et son emploi pour la prévision du Temps.—Première Etude sur le Minimum du Nuit.—Résumé Météorologique de l'année 1885 pour Genève et le Grand Saint-Bernard.

Klossovsky, Prof. A.—Les Orages en Russie.

Lancaster, A.—Tableaux-Résumés des Observations Météorologiques faites à Bruxelles pendant une période de cinquante années (1833-1882). I. Température de l'air.

Lee, G. J.—Meteorological Observations taken at Kimberley, South Africa, Dec. 1885 to Nov. 1886. (MS.)

Leupold, H.—Weather Maps of Davos Platz, Jan. to Sept. 1886. By C. Wetzel.

Leyst, E.—Beobachtung auffallender Blitze.

Liversidge, Prof., F.R.S.—President's Address delivered to the Royal Society of New South Wales, May 1886.

Mann, Dr. R. J.—Lightning Conductors.—By R. Anderson.

Marchand, M.—Climatologie de la ville de Fécamp. (MS.)

Mawley, E.—The Rosarian's Year Book, 1886.

McGregor, W.—Loss of Life and Property by Lightning at home and abroad.

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Philips, J. C.—Traces from Self-recording Aneroid at the Heath House, Tean, 1886.

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Soames, Rev. C.—Wiltshire Rainfall, Dec. 1885 to Dec. 1886.

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Symons, G. J., F.R.S.—British Rainfall, 1885.—De la Prévision du Temps à Courte Echéance à l'aide du Baromètre, dans le Département des Basses-Pyrénées. Par A. Piche.—Le Climat de Pau. Par A. Piche.—Oldham Water, 1886: Rainfall in the vicinity of proposed Gathering Grounds.—Symons's Monthly Meteorological Magazine, 1886.—Also several Papers relating to Biarritz Conference, 1886.

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Tebbutt, J.—Results of Meteorological Observations made at the Peninsula, Windsor, New South Wales, 1882-5.

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Tripe, Dr. J. W.—Reports on the Sanitary Condition of the Hackney District for the years 1881, 1883 and 1885.

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Tyrer, R.—The Meteorology of Cheltenham in 1885.

Upton, W.—The Distribution of Rainfall in New England, February 10 to 14, 1886.

Vaughan, J. D. W.—Meteorological Observations taken at Levuka and Suva, Fiji Islands, 1875 to 1885.

Ventosa, D. V.—El Huracán de Madrid.

Watson, Rev. J. S.—Meteorological Register kept at Guilsborough, Northamptonshire, 1815 to 1845. (MS.)

Weihrauch, Prof. K.—Ueber die Dynamischen Centra des Rotations-Ellipsoids, mit anwendung auf die Erde.—Ueber Pendelbewegung bei ablenkenden Kräften, nebst Anwendung auf das Foucalt'sche Pendel.

Wild, Dr. H.—Bestimmung der Inductionscoefficienten von Stahlmagneten.—Der Magnetische Bifilar-Theodolith.—Termins-Beobachtungen der Erdmagnetischen Elemente und Erdströme im Observatorium zu Pawlowsk vom Sept. 1832 bis Aug. 1883.

Woeikof, Dr. A.—Etude sur la Température des Eaux et sur les Variations de la Température du Globe.

Zenger, Prof. K. W.—Die Meteorologie der Sonne und ihres Systemes.—La Heliofotografia comparada con los grandes movimientos atmosféricos y seismicos.

APPENDIX VI.

REPORTS OF OBSERVATORIES, &c.

The Meteorological Office.—Lieut.-Gen. R. Strachey, R.E., C.S.I., F.R.S., Chairman of Council; Robert H. Scott, M.A., F.R.S., Secretary; Captain H. Toynbee, F.R.A.S., Marine Superintendent; Nav. Lieut. C. W. Baillie, F.R.A.S., Assistant do. There has been no change in the Council or staff of the office during the year.

Marine Meteorology.—The discussion of the Meteorology of the North Atlantic for the thirteen months August 1882 to August 1883 inclusive has made satisfactory progress and is in an advanced stage. The work will appear in four parts of 33 sheets each. The charts for the first part were signed for press in September, and those for the second part in January. The delay in issue of the work rests with the binders.

Progress has been made with the Red Sea work, and much information has been derived from remark books of the Royal Navy, the logs of the P. & O. Company, and from data supplied by the Royal Meteorological Institute of the Netherlands at Utrecht. Several of the charts of Barometrical Pressure for all oceans have been engraved. It is hoped that these will be completed during the year 1887.

The charts of Monthly Ocean Currents for all oceans are in hand.

Weather Telegraphy.—A considerable addition has been made to the number of continental stations sending in reports for 6 p.m., and through the great liberality of the Eastern Telegraph Co. reports for 8 a.m. and 6 p.m. are now received from Lisbon. The Corunna reports also arrive by the same route. The service of Transatlantic Telegrams has been materially modified, and for the last two months of the year telegrams have been received from the Chief Signal Office giving some facts as to the daily distribution of pressure over the United States as well as extracts from ships' logs. This service has been organised in conjunction with the French Meteorological Service.

The Weekly Weather Report has been modified, additional columns having been inserted on the first page. These give for each week the differences of the aggregate values of each element from the mean values to date. The volume for 1886 contains two special appendices, giving respectively (1) the weekly and progressive values for rainfall, accumulated temperature, and bright sunshine for each week in the two years 1885 and 1886; and (2) the mean aggregate values of the same elements for the 8 years 1878-85, from the beginning of the year up to the end of each week.

Land Meteorology of the British Islands.—Two parts of the *Quarterly Weather Report* for 1878 have been published, and the remaining parts will shortly appear. The *Hourly Readings* are issued up to July 1884. The volume for 1883 contained as an Appendix the results of the Harmonic Analysis of twelve years' thermograms, as mentioned in the Report for last year.

The work on the atmospheric disturbances connected with the Krakatoa eruption has been completed and handed in to the Royal Society.

The volume of *Observations at Stations of the Second Order* for 1882 has been published, and that for 1883 is fairly advanced. Returns have been supplied, as usual, to the Registrar-General for Ireland, and to Mr. Symons for *British Rainfall.* Full sized anemographs have been executed at Fleetwood and at North Shields.—*March 7th*, 1887.

ROYAL OBSERVATORY, GREENWICH.—W. H. M. Christie, M.A., F.R.S., Astronomer Royal. The old and the new apparatus for photographic record of the indications of the dry and wet-bulb thermometers have both been used during the year 1886, the old apparatus continuously, and the new sufficiently to obtain proper comparison between the indications of the two instruments at different seasons of the year. At the beginning of 1887 the new apparatus was brought into regular use.

The new apparatus is placed under a shed open to the north, but having louvre-boards attached as necessary on portions of the eastern, southern and western sides. The bulbs of the thermometers were at first carefully screened by protecting boards from any possible effect of radiation from the sky or ground. On various days of extreme heat during the year 1886 experiments were made by alternately removing and again affixing the principal (three) of these boards, for the purpose of determining what effect on the records was thus produced. It was found, on the average, that the records were practically identical with boards off or on. In December 1886 those boards with which experiment was made were finally removed. Certain experiments were also made on the ordinary frame carrying the standard thermometers, by alternately removing and affixing the circular board attached thereto in the year 1878 with the object of protecting the thermometers from ground radiation. It was found that with the board present or absent the thermometer readings were sensibly the same.

In January 1887 a Stevenson Screen of the pattern approved by the Royal Meteorological Society was erected in the Magnet Ground adjacent to the open stand carrying the standard thermometers for the purpose of comparing together the indications of the thermometers thus differently exposed.

A Campbell Sunshine instrument having the Stokes card arrangement was provided in the month of May 1886. This instrument together with the original Campbell form have since been both continuously used for the purpose of comparison of results. Commencing with January 1st, 1887, all published numbers will be those of the Stokes pattern of Campbell sunshine instrument.

It is proposed to reduce the photographic records of the barometer for the years 1874 to 1876, and for the dry and wet-bulb thermometers for the years 1869 to 1876, not previously done. This will complete the reduction of the photographic barometer records from 1854 to the present time, and those of the dry and wet-bulb thermometer records from 1849 to the present time.—*February 18th*, 1887.

ROYAL OBSERVATORY, EDINBURGH.—Professor C. Piazzi Smyth, F.R.S.E., Astronomer Royal for Scotland.—The bi-diurnal meteorological observations at fifty-five stations of the Scottish Meteorological Society have been computed, condensed, and described, partly every month, and wholly every quarter, for the Registrar-General of Births, Deaths, &c. in Scotland, in whose printed returns for months and quarters they have accordingly appeared.

The record of the Rock Thermometers in the Observatory grounds has been kept up as usual; but with an increased difficulty of reading the two intermediate instruments between the highest and lowest. On examination it was found that they had sunk sensibly in the soft filling of the deep bore-hole in the porphyry rock. Communication was opened immediately with Mr. Wedderburn, by whom, under the superintendence of the late Mr. Richard Adie, after the demise of his brother John Adie, that series of thermometers was made and established; and he, Mr. Wedderburn, was very sanguine of being able, when summer came, to raise them again to their former level. But meanwhile his own health failed, death supervened, and Edinburgh has lost a rising optician, and the last partner in the long established, almost historic, house of Adie and Wedderburn.—*January 8th*, 1887.

THE KEW OBSERVATORY OF THE ROYAL SOCIETY, RICHMOND, SURREY.—G. M. Whipple, B.Sc., F.R.A.S., Superintendent. The several self-recording instruments for the continuous registration respectively of atmospheric pressure, temperature and humidity, wind (direction and velocity), bright sunshine and rain, have been maintained in regular operation throughout the year. The standard eye observations for the control of the automatic records have been duly registered during the year, together with the daily observations in connection with the U.S. Signal Service synchronous system. The tabulation of the meteorological traces has been regularly carried on, and copies of these, as well as of the eye observations, with notes of weather, cloud and sunshine, have been transmitted to the Meteorological Office.

Acting upon the recommendation of the Kew Committee the Meteorological Council have purchased a new quadrant electrometer, constructed on Mr. de la Rue's principle with Professor Clifton's improvements, together with a chloride of silver battery of 60 cells, for the purpose of maintaining the potential of the quadrants at a certain point. By the kindness of the Chairman of the Committee (Mr. de la Rue), experiments were made at his laboratory in Portland Place by means of which the scale value of the instrument was determined before it was conveyed to the Observatory and erected in the place of the Thomson instrument formerly employed, but no change has been made in the recording apparatus attached to it. The instrument has been working for the past three months in a satisfactory manner.

In accordance with a request made by the Meteorological Council the electrograms for the two years 1882 and 1883 have been tabulated in absolute values.

The report on last year's work in cloud photography was duly submitted to the Meteorological Council, and placed by them in the hands of Professor Stokes for consideration. That gentleman having investigated the methods employed at the Observatory, devised a new graphic process for determining the cloud heights and motions in a much simpler manner than by the use of mathematical formulæ only. He invented a special apparatus called a projector, which has been constructed by Mr. C. Baker, and is now being utilised in the reduction of the pictures taken during the past year. These have amounted to 116 cloud negatives, and were obtained in 16 days. For convenience of dealing with the cloud pictures in the projection apparatus with greater facility, the negatives have all been printed off on paper prepared by the cyanotype process on the bromide paper.

At the request of the Council of the Royal Meteorological Society certain experiments were made with the view of investigating Professor W. K. Zenger's solar phenomena, and an examination was made also of the Kew solar photographs. The results obtained were, however, of a negative character only. A note of them has been published in the *Quarterly Journal Roy. Met. Soc.*, Vol. XII. p. 215.

A comparative trial extending over five months was made of Professor McLeod's sunshine recorder and the Stokes instrument which proved the results given by the two instruments to be practically identical.

The experiments with the solar radiation thermometers have been continued during the past summer months, and at times as many as eight instruments have been under observation. It having appeared that during the winter the *vacua* in certain of the instruments had deteriorated either by leakage or evolution of gas from the lamp-black coating of the bulbs, experiments were made in Mr. de la Rue's laboratory which proved that such was the case. New thermometers were made and enclosed in jackets not provided with platinum electrodes; the bulbs were also made of black glass, having the stems covered with black enamel. These, after careful exhaustion, were placed under observation, but did not register temperatures higher than had been previously observed. Advantage was taken of an offer kindly made by Professor Thorpe to make solar radiation observations on his recent Eclipse Expedition to Grenada, and two of the instruments were lent him. He has now returned them to the Observatory, together with copies of the readings he was able to make in tropical latitudes.

The Electrical Anemograph, after a lengthened trial in the Experimental House and the execution of certain minor alterations by Mr. Kempe, was dismounted and forwarded to the Valencia Observatory at the request of the Meteorological Council. The external parts were previously put in thorough repair by Mr. Munro, in order to fit the anemograph for the rough weather it will experience when erected on a hill almost overlooking the Atlantic.

Trials have been made of two anemometers constructed on a new principle by Mr. W. H. Dines, B.A.

Various experiments have been tried with the view of selecting a suitable paper for use with the Beckley anemographs, and also of remedying certain defects found attendant on the employment of gelatinised photographic curves in processes of mechanical reductions in the Meteorological Office.

The number of instruments verified during the past year amounted to about 11,600.—*January 24th*, 1887.

Radcliffe Observatory, Oxford.—E. J. Stone, M.A., F.R.S., Radcliffe Observer. No change in the instruments or in the method of observing has taken place during the year 1886. The meteorological day is still reckoned, as in previous years, from Greenwich mean noon.

The instruments are in good order and working satisfactorily; the thermometers were compared by Mr. G. M. Whipple, on September 11th, with a Kew standard, and in some instances the index errors were found to have slightly changed since the comparisons in 1884.

The photographic work, using, as in former years, the waxed paper process, was uniformly good until May, when a new stock of waxed paper was brought into use, and for a few months the results were most unsatisfactory; but recently alterations have been made in the formulæ used, and the finished pictures show considerable improvement and are satisfactory, yet decidedly inferior to those obtained with the old paper. The new paper, which, like the old paper, was made in Germany and obtained through the Kew Observatory, is of a different texture, being much thinner, very liable to tear, and scarcely withstands the necessary washing.

For some years a notice containing the meteorological readings taken at 8 a.m., with those of the previous day, also the Meteorological Office Forecast, has been exhibited at the outer gates of the Observatory ; this has attracted considerable attention ; it has been thought desirable to show the 2nd and 3rd page of the *Daily Weather Report* as well as our own readings, so that the public may have an opportunity of noticing the meteorological changes in progress.

Four rain gauges are in use, two on the ground, one at an elevation of 22 feet, and one on the Tower at the elevation of 112 feet. The rainfall, ground gauge, for the year 1886 was 32·687 ins., or as much as 6·103 ins. above the average for the last 36 years ; with the exception of 1852 (40·416 ins.) and 1875 (32·979 ins.) this rainfall is the largest recorded at this Observatory.

Bright sunshine was registered for about 1,400 hours, or 30 per cent. of the possible amount. A bright "Sun pillar" was seen here on June 5th. The highest recorded motion of the wind by the anemograph was 1,020 miles on March 30th, and 952 miles on December 8th ; and the greatest hourly runs were 50 miles on December 8th, 10-11 p.m., and 47 miles on March 31st, 2-3 p.m. The mean monthly temperature was below the average from August 1885 until June 1886 (inclusive), except for November 1885, which was 0°·7 above the average. The highest reading in 1886 was 83°·9 on July 4th, and the lowest was 14°·3 on January 8th. Out of the first 77 days of the year there was frost on the ground on 70 days.

Weather reports have been supplied daily (by telegram) to the Meteorological Office ; bi-monthly to the U.S. Signal Office ; monthly to the Registrar-General and the local newspapers ; and yearly to Symons's *British Rainfall*, and to some eminent meteorologists by request.

The *Meteorological Results* for 1883 have been printed and were distributed last summer, and those for 1884 will shortly be in the printer's hands, and will be published this summer. The observations made in 1885 and 1886 are partly reduced.—*January* 31*st*, 1887.

CAMBRIDGE OBSERVATORY.—Prof. J. C. Adams, F.R.S. The meteorological work has been carried on by Mr. H. Todd as in former years ; the readings being made at 8 a.m., 2 p.m., and 6 p.m., and the results forwarded to the Meteorological Office every morning. A half-yearly report is published in the *Cambridge Chronicle;* and whenever any unusual storm, &c. occurs an account of the same is sent to the same paper. The usual rainfall report has been forwarded to Mr. Symons. There has been no change in the instruments.—*January* 13*th*, 1887.

STONYHURST COLLEGE OBSERVATORY.—Rev. S. J. Perry, F.R.S. No change of any great importance has been made in the routine work. The meteorological, magnetic and astronomical departments have all received the usual attention, and the Rev. J. New was in charge of the Observatory during the absence of the Director in the West Indies, where he observed the total Solar Eclipse of August 29th, at the island of Carriacon. Some little time in the early part of the year was devoted to cloud photography, but the preparation of instruments for the total eclipse necessitated the deferring of all other extra work.—*January* 10*th*, 1887.

ON THE
IDENTITY OF CLOUD FORMS ALL OVER THE WORLD;
AND ON THE
General Principles by which their Indications must be read.

By the Hon. Ralph ABERCROMBY, F.R.Met.Soc.

[Read January 19th, 1887.]

I shall endeavour to illustrate the fact of the identity of cloud forms by exhibiting before the Society the following photographs, mostly taken by myself:—

Cumulus clouds in various longitudes, and in latitudes ranging from 64° N. lat. to 55° S.

Stratus, ranging from 72° N. to 43° S.

Cirrus, from 52° N. to 4° S.

Cirro-stratus, from 52° N. to 5° S.

Cirro-cumulus (fleecy cloud), from 52° N. to 51° S.

Strato-cumulus, from 52° N. to 18° S.

Besides miscellaneous forms of clouds, including some actually on the Equator.

From these pictures there can be no doubt of the identity of the forms of clouds, but it will be remarked that the surroundings and general atmosphere are so different that in some cases an experienced observer would see at once whether the photograph had been taken in the tropics or in temperate regions.

For instance, in the view of Rio Janeiro (Plate III. fig. 8 cumulo-nimbus), though the form of the cloud alone is hardly distinguishable from that of a cumulus taken in London, still there is a clearness in the outline of the town and a calmness of the sea which could not have been found in England.

Again, in the picture of a tropical sunset in 4° S. 32° W. (exhibited at the Meeting), there is a glow of light behind the dark, sharp outlined cumulus, and a beautifully lighted stripe of cirrus above, which could neither have been seen in England nor have been reproduced by an artist.

So also in the photographs of strato-cumulus from the South-east Trade (Plate III. fig. 6), there is a hardness of cloud form, a sharpness of the horizon, a general brightness and crispness of curl on the water which we never observe at home.

In northern climates there is usually so much haze in the air that the outlines of the clouds, especially near the horizon, are more or less misty, and this effect is always exaggerated in a photograph. For instance, the author once observed at Archangel, with a North-east wind, some small detached cumulus, which by form alone were hardly to be distinguished from similar clouds in the North-east Trade; but there was a paleness about the colouring, a slight refraction on the horizon, to say nothing of the surrounding vegetation, which effectually marked the real difference between the localities of the two clouds.

We shall now make a few remarks on the geographical distribution of the various forms of cloud, for some clouds are far more common in some latitudes than others. For instance, cumulus is never seen in northern Europe during the winter months, and is, we believe, very rare in the true Arctic regions. By the true Arctic regions, we mean the domain of perpetual snow and ice, for we have seen some small, poor cumulus clouds within the Arctic circle off the coast of Norway, in the early autumn. On the other hand, we have never but once observed within the tropics those beautiful forms of cirro-stratus in which the long filaments of cloud cross each other like the threads of a net or web, that are among the most beautiful skies of our northern climate.

Roughly speaking, the commonest cloud in the tropics is cumulus, with or without a thin layer of light pure cirrus at a higher level. In the middle latitudes, including Great Britain, and especially at sea, the mixed clouds known as strato-cumulus and irregular cirro-stratus are the most frequent. By strato-cumulus we mean a layer of cloud, not flat enough to be called pure stratus, but rising into lumps too irregular and not sufficiently rocky to be called true cumulus.

Farther north, as we have just said, cumulus seems almost to disappear in any form, and the air is filled with fog or mist which rises at times into ill-defined stratiform clouds. If we take a broad view of clouds, it is a very noticeable fact, that while certain common forms are not only universal, they are also persistent; while other rarer forms are only developed occasionally, under exceptional circumstances. For instance common cumulus, wispy cirrus, and fleecy clouds (cirro-cumulus) are not only universal, but may be visible for hours together, especially the first two kinds; while festooned clouds, mackerel sky and some others are seldom seen at all, and usually only last for a few minutes at a time.

So much is this so, that if we take cirrus, stratus and cumulus in their usually accepted forms, and further define—

Cirro-stratus as the whole class of thin stratiform veil clouds that are more or less hairy or thready, at any level;

Cirro-cumulus as fleecy sky at any level, that is to say, excluding from that term the mackerel sky and the long line of little lumps of cloud, sometimes called high cumulus or thunder-heads;

Strato-cumulus as that irregular flat cloud which is too lumpy to be called stratus, and not rocky enough to be classed as cumulus;

Nimbus as any cloud from which rain or snow is falling;—

Then, as far as the author's experience goes, 90 per cent. of skies all over the world could be fairly described by these seven words. This of course only applies to the broad features of any sky, for no two skies are ever exactly alike any more than any two faces, and specialists in clouds will of course prefer a more minute classification; but for ordinary observers, and on board ship, we believe that the above is sufficient for most practical purposes.

We now come to the second portion of this paper, the general principles by which we must read cloud forms so as to deduce useful indications from them as to the future weather. Cloud forms are the same all over the world, but the weather prognosticated by any particular shape is not the same. For instance, even in England we can see wispy windy looking cirrus any fine summer evening that really indicates fine weather; but which by form alone cannot be distinguished from the mare's tails on the southern edge of a cyclone that indicate wind and possibly rain.

Still more is this the case when we compare the cloud prognostics of different countries, For example, in Scotland, when the long stripy cloud, popularly known as "Noah's ark," stretches east to west it is a sign of a storm; but when north and south then of fine weather. But in the Eifel district of the Lower Rhine, on the contrary, they say that when the "cloud ship" turns its head to the south, rain will soon follow.

We have already adverted to the similarity of what we may call fine weather and dangerous cirrus in England; and Padre Faura, of the observatory in Manilla, told us that one can often only distinguish the ordinary cirrus of a fine day, from that which precedes a typhoon, by observing whether the wisps disappear after sunset. Of course this refers to the form of the cloud alone, for there are always numerous other surroundings, such as a falling barometer and irregular wind, which give abundant warning of the advent of a typhoon.

Again, as regards fleecy cirro-cumulus, there is an English couplet—

"If woolly fleeces spread the heavenly way,
Be sure no rain disturbs the summer's day."

The French have a similar proverb, "El ciel pecoun promete un bel matin."

But in Italy, on the contrary, they say in the neighbourhood of Pisa—

"Cielo a pecorelle,
Acqua a catinelle."

And Virgil expresses the same idea in the line—

"Tenuia nec lanæ per cœlum vellera ferri."

While in the tropics we have observed that fleecy clouds are not associated with any particular kind of weather.

So also as regards the festooned cumulus, to which Dr. Clouston first called attention, as the sign of a storm in the Orkneys. In Lancashire, the same appearance of cloud is called "rain balls," and rain rather than wind is expected; while in the tropics, in countries where cyclones are unknown, these festoons are very common in connection with thunderstorms.

Numerous other instances might be adduced; but if we discuss the above examples *seriatim*, the nature of the general principles, by the light of which the prognostic value of clouds must always be read, will be abundantly explained.

The difference between the fine weather and dangerous cirrus of England can be readily detected, if we not only look at the surroundings but also at the origin and development of the cloud wisps. Take a fine summer evening, the sky in the afternoon has been covered with clear detached cumulus, with a pleasant gentle Westerly breeze. Towards 5 p.m. the rockiness of the clouds begins to diminish, and gradually by sunset the sky is covered by long wisps of stripy cirrus; but this soon disappears, and by 9 p.m. the sky is probably cloudless. In addition to all this there is the indescribable way in which the wind blows gently and has fallen regularly since midday, besides the general serene appearance of the sky.

Now contrast this with the wispy cirrus which precedes a winter gale, at any time of the day. The weather immediately preceding has probably been fine, but now the wind has fallen unnaturally, and the blue of the sky has begun to sicken and to grow pale. Then long streaks of cirrus seem to grow out of the air—not replacing cumulus, as in the former instance,—and gradually the stripes grow denser and denser till they lose all cirrus form, and the sky becomes dirty and overcast, till the drizzling rain of a cyclone front sets steadily in.

In Manilla, where the diurnal sequence of weather is much more regular than in England, the non-disappearance of the ordinary diurnal cirrus at sunset shows that some exceptional cause is at work.

Unfortunately the origin of wispy cirrus is uncertain in many cases, so that we can only note the difference of surroundings, but not explain the reasons of the varying import of this kind of cloud.

The explanation of the contradictory sayings about the direction in which the cirrus stripes lie—the "ark" and "sea ship" are popular names for the appearance of long parallel cirrus stripes seen in perspective—is more difficult, but seems to be as follows:—In the right front of a primary cyclone, cirrus stripes usually lie about east and west; and so far would indicate the approach of rain. Stripes running north and south would be formed, on the contrary, either at the extreme edge of a cyclone going north, some way to the west of the observer, or at the north or north-east edge of an anticyclone; and in neither case need rain or wind be anticipated. We are indebted to the Rev. W. Clement Ley for pointing out these two last cases.

As we have never observed the "cloud ship" in Rhineland, we can say very little about it, but probably it may turn its head to the south before the rain of a thunderstorm or of a secondary cyclone, and then we can readily understand that the conditions of surface and upper currents which determine the lie of a cirrus stripe would not be the same as in a primary cyclone in northern Europe.

Then again we have to explain why fleecy clouds should presage fine weather in England but rain in Italy, and should indicate no particular weather in the tropics. As a matter of observation, fleecy clouds are formed in the temperate zone either at the edge of an anticyclone or in front of thunderstorms, and of that peculiar class of rainfall which is not shown on isobaric charts at all. Within the tropics we have not enough accurate isobars except in India to correlate this form of cloud with any particular system of atmospheric circulation; but fleecy clouds are tolerably common in the Trade Wind regions, and do not seem to have there any particular significance either for good or bad weather.

The origin of the fleecy appearance of cloud is unfortunately unknown, but the practical significance of the apparently contradictory prognostics is probably due to the fact that the bulk of British rain is cyclonic, and therefore not preceded by fleecy clouds; while the edge of an anticyclone which develops fleecy clouds is naturally associated with fine weather. In Italy the principal rainfall is with thunderstorms, and there this woolly look of the sky may be a good precursor of rain. In the tropics we can do no more at present than note the fact that this form of cloud has no particular value as an indication of the coming weather, but the examples of Great Britain and Italy will abundantly show that the prognostic value of these clouds, like all others, must be interpreted by the surroundings and general character of the meteorology of the country in which they are observed.

The reason why festooned cumulus should indicate a gale in Orkney, and only rain in England or in the tropics, is fortunately very simple. The author has shown in *Nature*, for May 24th, 1883, that by watching the transitional and developmental forms of cumulus, we can find the origin of the drooping festoons of cloud in the sudden failure of an ascensional current of damp air. When a column of damp air rises steadily into a cold stratum, the vapour is condensed into a flat based, rocky topped mass of cloud. If the rising current suddenly fails, the condensed globules begin to fall in a well-defined festoon; but if the failure is more gradual, then the cloud degenerates into raggy and not into festooned masses. This sudden failure of uptake is characteristic of squalls, and the front of thunderstorms or heavy showers; so that the prognostic value of the appearance must be judged by the place of a squall or shower in the meteorology of the country where the festoons are observed. For instance, in Orkney Dr. Clouston saw the festoons associated with a squall in rear of an ordinary cyclone; the festoons are only an accompaniment of that squall, but they are also a true precursor of a gale the next or following day, because the nature of cyclones in that part of the world is to follow one another closely. In England, which lies more out of the track of Atlantic cyclones, the sequence of storms is not so regular; and the "rain balls" are usually seen just in front of a heavy rain cloud, and they have no prognostic value for the following days. Still more is this the case in the tropics, for we have frequently seen these festoons in Borneo and other countries where cyclones are unknown.

But we can get a more striking example of these principles by considering the origin and import of cumulus clouds. All cumulus is the visible capital of an ascensional column of damp air which has reached the level of condensation; but the cause of the uptake need not be, and is not, the same in all cases. In England the uptake may be determined either by that complex vortex which we call a cyclone, or by the evaporation of a fine morning. The former cause is generally sufficiently intense to develop rain; the latter cause is indicative of fine weather. The beautiful cirrifying cumulus which was shown from Borneo was caused by a collision between the land and sea breezes, and was associated with heavy rain. Here then we have three sources of cumulus—cyclone, evaporation, collision—and the cloud will manifestly portend different weather in each case. When we see a cumulus cloud, all it tells for certain is that a column of air is rising. Our own judgment and experience must tell us why the air is rising, and from that what the coming weather will be.

The foregoing examples will illustrate the general principle of interpreting cloud forms by their surroundings which I wish to emphasise in this Paper and prove that shape alone is not sufficient to give a true prognostic value. Clouds always tell a true story, but one which is difficult to read; and the language of England is not the language of Borneo. The form alone is equivocal; the true import must be judged by the surroundings, just as the meaning of many words is only known by the context.

The following is a list of the photographs exhibited at the Meeting on January 19th, 1887:—

The whole of the slides, except Nos. 1, 8, and 11, were from photographs taken by Mr. Abercromby.

No.	FORM OF CLOUD.		Lat.	Long.
			°	°
1	Cumulus.	Archangel	64 N.	40 E.
2	,,	London	52 N.	0
3	,,	Atlantic Doldrums	9 N.	26 W.
4	,,	Atlantic actually on the Equator	0	30 W.
5	,,	,, steamy haze, actually on Equator	0	11 W.
6	,,	N.W. Monsoon, Indian Ocean	1 S.	83 E.
7	,,	S.E. Trade Atlantic	10 S.	2 W.
8	,,	Fiji	20 S.	180 W.
9	,,	S.E. Trade Atlantic, near Santos	28 S.	45 W.
10	,,	Reefing topsails in the S. Pacific	55 S.	96 W.
11	Stratus.	The Midnight Sun in Norway	72 N.	28 E.
12	,,	London. Typical E. wind type	52 N.	0
13	,,	Ohinemotu, New Zealand	38 S.	78 E.
14	Cirrus.	Norwood. In front of a cyclone	52 N.	0
15	,,	Stripes. Folkestone	51 N.	1 E.
16	,,	Sunset in the Tropics	4 S.	32 W.
17	Cirro-Stratus.	London. In front of a cyclone	52 N.	0
18	,,	,, With fine weather	52 N.	0
19	,,	Folkestone	51 N.	1 E.
20	Strato-Cirrus.	N.W. Monsoon, Indian Ocean	5 S.	89 E.
21	Cirro-Cumulus.	High fleecy cloud. Falkland Islands	52 S.	62 W.
22	Cumulo-Cirrus.	Low fleecy cloud. Folkestone	51 N.	1 E.
23	,,	,, Atlantic Doldrums	8 N.	25 W.
24	Strato-Cumulus.	Folkestone	51 N.	1 E.
25	,,	Teneriffe, N.E. Trade	31 N.	18 W.
26	,,	S.E. Trade, Roll Cumulus	8 S.	4 E.
27	Nimbus.	A ragged cloud. London	52 N.	0
28	Cumulo-Nimbus.	London	52 N.	0
29	,,	Cirrifying above. Borneo	5 N.	119 E.

No.	FORM OF CLOUD—*Continued.*	Lat. °	Long. °
80	CUMULO-NIMBUS. Rio Janeiro	22 S.	45 W.
81	UNCLASSIFIED. False Cirrus. London	52 N.	0
82	„ „ „	52 N.	0
83	„ "Banner" cloud trailing from Kanching Junga, 28,000 ft. Taken from 10,000 ft.		
34	„ Do. Do.		
85	„ Mist in the Himalayas		
86	„ Clouds driving in front of the Himalayas at Sunset................		

NOTE ADDED JAN. 1887.

[Since the above Paper was written, the author has had the advantage of conversing with Mr. N. Ekholm, of Upsala, who spent fourteen months with a Swedish scientific expedition in Spitzbergen. He assured him that cloud forms in that Island are the same as in Sweden, but that the cumulus is never very firm. The fact of the identity of cloud forms all over the world seems, therefore, to be established conclusively.

The author wishes to correct an impression which appears to have been conveyed to the Meeting, that the universality of cloud forms diminishes the value of clouds as indicators of coming weather. The great principle of the development of particular kinds of cloud in different parts of a cyclone, anticyclone, or in straight isobars, holds good in this country; only we now know that the same cloud may be formed under different circumstances in other parts of the world.]

DISCUSSION.

Mr. **WHIPPLE** said he could testify from his own experience to the extreme difficulty of obtaining good cloud photographs. He had been engaged for two or three years past in obtaining photographic cloud pictures, and if in a well-equipped observatory successful cloud photography was not an easy matter, how much more difficult must it have been for Mr. Abercromby to obtain pictures so good as had been shown on the screen that evening, considering the great disadvantages under which the photographs were taken. He felt sure the photographs exhibited represented but a small percentage of negatives Mr. Abercromby must have procured. He could quite bear out Mr. Abercromby's remarks as to the close resemblance the cloud-forms exhibited with the forms observed in England, and also would confirm the statement as to the astonishing rapidity with which clouds changed their shape. In the investigations he himself was carrying out for the Meteorological Council on the heights and rates of motion of clouds, it was necessary to obtain a set of four pictures of the same cloud; he found it exceedingly difficult in the four photographs to identify the same point in all of them, even when only an interval of one minute had elapsed between the taking of the pair of pictures.

Mr. **GASTER** said the photographs exhibited by Mr. Abercromby were the most beautiful cloud pictures he had ever seen. He hoped that some attempt would be made to classify the different forms, it being very desirable that something should be done at once in the matter of classification.

Mr. **ARCHIBALD** said that the identity of cloud-forms all over the world was clearly shown in the pictures exhibited. He had lived for some years in India, and could certainly state that the forms of cloud to be seen in Bengal were practically identical with those common in England. The only difference was one of magnitude, everything in the tropics being produced on a grander scale than in temperate regions.

ON THE CLOUD
TO WHICH THE NAME OF
"ROLL CUMULUS"
HAS BEEN APPLIED.

BY THE HON. RALPH ABERCROMBY, F.R.MET.SOC.

[Read January 19th, 1887.]

THE cloud to which the name of "Roll Cumulus" has been applied is figured in the publications of the Meteorological Office of London, as a series of parallel bars of cloud. Apparently not associated with bad weather, it was reported as being particularly frequent in the districts covered by the Trade Winds, but not to be entirely confined to those latitudes.

In the course of my voyages I have frequently observed this appearance of cloud, and have also succeeded in taking several satisfactory photographs in various latitudes.

The general appearance of this cloud will be best judged from inspection of a photograph, taken on board the s.s. *Tongariro* on July 10th, 1885, in latitude 31° N. longitude 15° W., that is to say in the North-east Trade, not far from Teneriffe. There it will be seen at once that, towards the horizon, the clouds appear to be ranged in parallel bars, but that nearer overhead there are only the bases of irregular masses of cloud, without any attempt at parallelism.

The curious thing is, that whichever way one looks there is always the same parallelism, and none of the convergence of cirrus stripes. This of itself would prove that the appearance of bars is subjective, and simply a matter of perspective.

It is very obvious from the photograph, and from the other examples which have been exhibited before the Society, that the sky is really covered with detached masses of thin Stratus or Strato-cumulus; that overhead, there is no appearance of regular arrangement; but that as we approach the horizon and view the thin masses of cloud end-on, we see by perspective a series of lines one above the other whichever way we turn.

As the multiplication of cloud names is a serious inconvenience, I think that this form of cloud should be reported as Stratus or Strato-cumulus, according as the component masses partake more or less of the character of one or other of these clouds. I think that in the case given in the photograph the cloud should be called Strato-cumulus.

REMARKS CONCERNING THE NOMENCLATURE OF CLOUDS FOR ORDINARY USE.

By Prof. H. HILDEBRAND HILDEBRANDSSON, Hon.Mem.R.Met.Soc.

[Read February 16th, 1887.]

The problem of devising an International nomenclature of clouds is a difficult one. It seems that we must consider it from two different points of view. These are—1. How we shall best study the relation between the forms of the different clouds and the different forces at work in the air; and 2. How we shall determine as minutely as possible the relation between these forms and the weather changes. The question thus formulated is of the highest theoretical and practical interest, and for its solution it is necessary to study the clouds as minutely as possible; of course we must have a copious nomenclature, with many forms and subdivisions of forms. Mr. Ley has in this particular supplied us with an excellent nomenclature of the higher clouds, and we shall be exceedingly glad if he will furnish a corresponding nomenclature for the lower clouds also. I have worked a long time at the clouds; and I am sure that I can appreciate the great scientific value of Mr. Ley's excellent work.

Yet it seems to me scarcely possible, that every ordinary observer or seaman could be expected to use such a copious nomenclature. One must have had a long experience in cloud-observation, and possess a trained eye, to be able to work with such delicate forms without incessant mistakes. Happily this is not necessary for many purposes. These finer investigations must always be executed by persons having a personal interest in them. Of course, they must be reserved for first-class observatories or for specialists.[1]

But if we will not go so far for common use, it would certainly be of great importance if we could have a simple, practical and international nomenclature of clouds. As we shall see below, the observers of most countries have the names of most of the typical cloud forms,—ten in number,—but there exists a great confusion regarding the clouds to which the names are applied.

The question, it seems to me, may also be put thus: If it is true, that for the present time it is of the highest importance to get trustworthy observations of the directions of the atmospheric currents at different heights above the sea-level, and under different atmospheric conditions at as many places as possible, how many typical forms of clouds must be observed ?

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[1] It would be of the highest interest, and extremely useful, if a society of persons, specially interested for cloud studies, would continue to observe systematically over a great part of the world, keeping strictly to the same detailed nomenclature, *e.g.* that of Clement Ley.

As stated before, these forms are ten, or at least nine in number.

In fact we have the following arrangement of clouds :—

TABLE I.

A. Clouds in connection with the general movements in the air.

(*a.*) Highest fine clouds (9,000 metres).[1]

1. In form of feathers, &c. (Cirrus).

2. Fine *thin* veil (Cirro-stratus), often with halos, &c.

(*b.*) Fine-weather clouds, round forms, often with intervals of blue sky.

3. *Small, pure, snow-white* balls or grains (Cirro-cumulus), 6,500 metres.

4. *Greater, cotton-like* balls (Alto-cumulus), 4,000 metres.

5. *Great, grey* balls or rolls (Strato-cumulus), 2,000 metres.

(*c.*) Foul weather forms, flat forms stretched out as a veil.

6. *Thicker, greyish* to *blueish* veil or sheet (Cirro-stratus, Kämtz), 5,000 metres.

7. Rain clouds, dense masses of dark clouds with fringed edges (Nimbus), 1,500 metres.

B. Condensations in the lowest strata.

8. Mist floating in the air, not resting on the ground as fog (Stratus), below 1,000 metres.

C. Clouds formed by the ascending current.

9. True *cumulus*-clouds, usually with *flat* base and *rounded tops.*

(Top 2,000 m.; base 1,500 m.)

10. The above cloud towering up to colossal proportions as mountain ranges, or a gigantic mushroom, with a flat layer of "false cirrus" around or on the top.[2] (Cumulo-stratus.)

(Top 3,000 m.; base 1,500 m.)

The tops of this form are often enveloped by a veil of "*false cirrus,*" which seems in some cases to flow out on a level with the top.

The names employed in the above scheme are those used in Upsala,[3] and for the most part in other countries also.

In fact we have, as far as we could find, the following schemes for other countries.

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[1] The heights of the clouds are given in round numbers from the new measurements of M.M. Ekholm and Hagström in Upsala.

[2] This form of cloud being not very common, it would perhaps be better to introduce the name cumulo-nimbus for all forms of raincloud with rocky cumulus tops, the cumulo-stratus being only a special variety of them.

[3] *Sur la classification des nuages employée à l'observatoire meteorologique d'Upsala*, par H. Hildebrand Hildebrandsson, avec photographies de M. Henri Osti. 2nd Ed., Upsala, 1881.

II. English and Swedish Marine.[1]

A.

1. Cirrus
2. Cirrus or Cirro-stratus
3. Cirro-cumulus
4.
5. { Roll-cumulus (Strato-cumulus)
6. Cirro-stratus
7. Nimbus

B.

8. Stratus

C.

9. Cumulus
10. Cumulo-stratus

III. Norway.[2]

A.

1. Cirrus
2. Cirro-stratus
3. Cirro-cumulus
4.
5. Cumulo-stratus
6. Cirro-stratus (?)
7. Nimbus

B.

8. Stratus

C.

9. Cumulus
10. Nimbus

IV. Swedish Meteorological Institute.[3]

A.

1. Cirrus, and
2. Cirrus
3. Cirro-cumulus
4.
5. Strato-cumulus
6. Cirro-stratus
7. Nimbus

B.

8. Stratus

C.

9. Cumulus
10. Cumulo-stratus

V. Portugal.[4]

A.

1. Cirrus
2. Cirro-stratus
3. Cirro-cumulus
4. Cumulo-cirrus
5. Cumulo-nimbus
6. Strato-cirrus
7. Nimbus

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[1] Robert H. Scott: *Instructions in the Use of Meteorological Instruments.* (Official, No. 24.) London, 1875; and *Instruktion för meteorologisk loggboks förande, af Nautisk-meteorologiska Byran.* Stockholm, 1879.

[2] Mohn: *Grundzüge der Meteorologie.* 3te Auflage, s. 183.

[3] Edlund: *Handeldnind vid meteorologiska Observationers Anställande.* 2nd Ed. by Hamberg. Stockholm, 1882.

[4] Brito-Capello: *Annaes do Observatorio do Infante D. Luis.*

B.

8. Stratus

C.

9. Cumulus
10. Cumulo-stratus

VI. GERMANY. DEUTSCHE SEEWARTE.[1]

A.

1. Cirrus, and
2. Cirrus
3. Cirro-cumulus
4. Cirro-stratus[2]
5. { Strato-cumulus
Wulst-cumulus
6.
7. Nimbus

B.

8. Stratus

C.

9. Cumulus
10. Cumulo-stratus

VII. FRANCE.

It does not seem that any well-fixed nomenclature actually exists in this country. In a letter of July 15th, 1877, M. Renou indicates the forms employed at that time at Parc St. Maur.[3]

A.

1. K
2. Ꝃ
3. KC
4. A
5. Ꞓ
6. ꝂꞒ
7. Ꞓ

B.

8. ?

C.

9. C
10. N

Now in the tables from Parc St. Maur inserted into the *Annales du Bureau Météorologique de France* we find only: K cirrus, K K cirro-stratus, A nuages étalés (stratus), A A alto-stratus, C cumulus, C C cumulo-stratus. We do not understand why this deterioration has been made.

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[1] Heuer: *Abbildung der verschiedenen wolkenformen.*

[2] The cloud form represented in the cloud map and marked cirro-stratus is difficult to understand, but looks *most like* the alto-cumulus of Upsala; yet it is very uncertain.

[3] "Je distingue les *cirrus* K, *primitifs*, c'est-à-dire en filament droits simples parallèles, *en barbe de plume* ou en *arête de poisson*, *floconneux* en touffes irrégulières.

Cirro-cumulus K C purement pommelés, dérivent des K qui s'abaissent.

Alto-cumulus A, qui sont des K C encore abaissés ou inversement des C étalés.

Des *cumulus* proprement dits.

Tous ces nuages réunies en couche, s'appellent *cirro-stratus*. K (et), ꝂꞒ, Ꞓ.

Enfin viennent les *nimbus* de Howard. On a appliqué cette dénomination seulement à des C épais. Elle ne doit s'appliquer qu'à une masse orageuse compacte, qui comprend par son épaisseur et sa grande hauteur toutes les autres couches de nuages ; ce sont essentiellement les couches à grêle et à orages."

In the observatory at Perpignan we have the following forms: K cirrus, K-C cirro-cumulus, K-S cirro-stratus, N nimbus, V voilé uniformement.

It is of no importance to make further comparisons; as we see, the fullest and perhaps best scheme is that of Portugal (Table V.). They have a special name for each of the ten typical forms, and the names are formed by alternating between the four well-known expressions: cirrus, cumulus, stratus, and nimbus. The combinations of these four words indicate in a manner easily to be understood the form and height of the cloud in question. Only the term cumulo-nimbus might give place to a misunderstanding. On a warm summer day the true nimbus is often seen, as said before, to approach to the cumulus form, the detached masses beginning to tower up with rounded tops. But these clouds, which could properly be called cumulo-nimbus, have nothing to do with No. 5, or the strato-cumulus of Sweden and Germany, or the roll-cumulus of the English meteorological log.

Next to Portugal comes Upsala (Table I.). Of course we have denominations for nine out of ten forms; the lower form of cirro-stratus, the cirro-stratus in the nomenclature of Kämtz, or the strato-cirrus in Portugal, is wanting. The English and Swedish Navy as well as the Royal Swedish Institute (Table II. and IV.) seems to confound 1 and 2, the *high* thinnest form of cirro-stratus being annotated as cirrus. They also want 4, the alto-cumulus of Upsala and of M. Renou, the cumulo-cirrus of Portugal.

The new French nomenclature is very incomplete.

In Germany (Deutsche Seewarte) there seems to be some confusion about 4 and 6, and the highest cirro-stratus is called cirrus, but on the other hand 5 is divided into two forms, viz. strato-cumulus and Wulst-cumulus.

Now the question arises, if it is necessary to adopt ten cloud forms, or if we could, for practical use, be content with fewer. But I do not believe this. If we go through the list, we have first—1 *Cirrus*, 3 *Cirro-cumulus* and 9 *Cumulus*, which are used by all. 7 *Nimbus* is also in common use. In Norway it is confounded with 10, the thunder-cloud or cumulo-stratus.

Then the question is simplified and reduced thus: must we distinguish 4, the alto-cumulus of Upsala and of France, the cumulo-cirrus of Portugal, from 3, the cirro-cumulus, and 5, the strato-cumulus, as well as 2, high cirro-stratus, from 6, low cirro-stratus or the strato-cirrus from Portugal.

As to the first question, it seems to me very good to retain or to introduce a form between the cirro-cumulus and the strato-cumulus [roll-cumulus, wulst-cumulus or cumulo-nimbus]. The cirro-cumulus has a mean height of 6,500 m., the strato-cumulus of only 2,000. The cumulo-cirrus or alto-cumulus again floats at an intermediate level of 4,000 metres. The motion of the clouds of all this class of cloud-forms is very easy to observe. Of course, if these three forms are adopted, we shall soon have materials to determine the directions of the air-currents at these three levels. If we do not keep them apart, there will be a great confusion. The intermediate layer would probably, in most cases, be reckoned with the cirro-cumulus, because the *white*, *cotton*-like alto-cumulus or cumulo-cirrus clouds much more resemble the *snow-white* little cirro-cumulus than the *dark*, *grey balls* or *rolls* of strato-cumulus. But then the mean height of cirro-cumulus will be considerably lower,[1] and the result will be a false one, so much the more as it is proved by the measures at Upsala that sometimes unusually thin and light strato-cumuli are mistaken for alto-cumulus. Should these clouds be reckoned among the cirro-cumuli, as I am sure they sometimes are in certain countries, the confusion would of course be still greater. If the eye is trained from the beginning to keep the three forms apart, it is not so difficult to observe the clouds as if it is only accustomed to two. The alto-cumulus was introduced in the journal at Upsala first in 1880, because before we were constantly embarrassed. The clouds were apparently too low or too dark to be cirro-cumuli, but too light and white to be placed among the strato-cumuli; and still worse, we had often to remark two layers of cirro-cumulus at very different heights and with totally different motions.

What has been said here applies to the higher and lower cirro-stratus. The high white cirro-stratus, with halos, mock-suns, &c., is probably the highest of all clouds; the lower, on the contrary, is at the level of only 5,000 metres. The difference goes up to more than 4,000 metres. It is true that we have not always to do with typical forms. On the contrary, the majority of clouds are intermediate forms. The cirrus clouds are gradually transformed into cirro-cumuli, the cirro-cumuli into alto-cumuli, and these into strato-cumuli. Yet the typical forms are easily learned, and in every case one must put down the type which most closely resembles the observed form.

As to the denominations, I think the Portuguese nomenclature the most practical, with the exception that Cumulo-nimbus should be replaced by Strato-cumulus, and perhaps be employed in place of Cumulo-stratus. I am willing, for my part, to accept this nomenclature, if it is adopted by some other country or navy.

In fact it is very simple to change Cirro-cumulus to Cumulo-cirrus, or Cirro-stratus to Strato-cirrus, and thereby indicate a higher or lower layer of the same sort of clouds. To sum up—I do not believe it wise and practical to accept for ordinary use a very complicated nomenclature of clouds, but on the other hand I do not think we can have less than the ten very well-defined types defined above.

I suppose every seaman easily recognises the true Cirrus and Cumulus, the common rain-cloud: Nimbus, and the mist floating in the air as a grey layer or in fantastic shapes: Stratus. He also recognises the thunder clouds often surrounded by false Cirrus: Cumulo-stratus, the Strato-cumulus, or Roll-cumulus, the "Ciel moutonné" by little snow-white Cirro-cumulus, and the rain-foreboding white sheet of Cirro-stratus, with its halos and mocksuns. We have only to tell him: if the Cirro-cumulus seems low and cotton-like, floating in somewhat denser masses, he must enter Cumulo-cirrus instead of Cirro-cumulus, and if the veil of Cirro-stratus becomes dark and threatening, he must put in the journal Strato-cirrus instead of Cirro-stratus.

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[1] For this reason the cirro-cumulus must be placed among the *lower* clouds if the direction of clouds are observed for *upper* and *lower* clouds separately, without any regard to different forms. *Report to the International Meteorological Committee*, by J. C. de Brito Capello, H. Hildebrand Hildebrandsson and Clement Ley. See *Report of the Third Meeting of the International Meteorological Committee*, Paris, 1885. Appendix III.

If the sky is *totally overcast* and the forms indiscernible, no outlines being visible at all, as sometimes happens during the day and often at night, in fog, etc., this must be marked by some sign, as for instance by *10, as used at Upsala.

SUGGESTIONS FOR AN

INTERNATIONAL NOMENCLATURE OF CLOUDS.

By the Hon. RALPH ABERCROMBY, F.R.Met.Soc.

Plate III.

[Read February 16th, 1887.]

At the last meeting I have shown that cloud forms are the same all over the world, though the weather indication of the same form may differ greatly in different latitudes, and accordingly the question of an International Nomenclature of Clouds becomes of the highest importance.

In the course of my travels, I have had the opportunity of conversing with the Directors of many Meteorological Institutes in various parts of the world, and have found that though some forms of cloud were almost universally assigned the same name, others—especially the lower clouds—received a different name from nearly every Director.

One difficulty in the way of any accordance of nomenclature arises from the impossibility of expressing the varying forms of clouds in words; and I have long been driven to the conclusion that no international accordance of cloud names can be obtained till typical photographs could be circulated at a moderate price. But though photographs are infinitely better than drawings or engravings, it must be borne in mind that both colour and distance are lost in photography, though the form is accurately reproduced. This is especially the case at sunrise and sunset, when pictures are most easily taken. Hence photographs of clouds do not give the important element of cloud nomenclature which concerns their height, and sometimes it is difficult to see the difference between the driving scud of nimbus and the rising mist of fine weather stratus.

For more than ten years past I have been endeavouring to get suitable pictures or photographs of clouds from every possible source without success. The pictures were usually pretty, but wanted point meteorologically; the photographs were almost all of cumulus, and the rarer forms were never procurable. Even when a few suitable pictures had been obtained, there remained the further question of their reproduction. Some attempts I made to get fleecy clouds engraved were expensive failures; and the photographs were often of unsuitable size, and the owners were unwilling to part with the negatives except at prohibitive prices.

Hence about three years ago I was driven to the conclusion that if the work was to be done at all, I must undertake the photography myself. The practical difficulties of cloud photography are numerous, for besides the difficulty of getting clear pictures on gelatine plates, the time required to obtain good results is very great. Sometimes half-a-dozen plates will be fogged before a good picture can be obtained, and I have often had to wait watching a cloud for a couple of hours before a suitable light could be found. Cloud forms are so transient, that sometimes after a good picture has been focussed on the ground glass, the character will have disappeared before the dark slide can be arranged.

However, in spite of numerous failures, I have succeeded in obtaining a large number of typical cloud photographs all over the world,—*carte de visite* size, which could be reproduced cheaply—by the end of last year, and then the question arose what names should be assigned them. I therefore determined to proceed to Upsala, and confer with Prof. Hildebrandsson on the matter.

My primary idea—in which Prof. Hildebrandsson entirely concurred—was that the name of a cloud is of far less importance than that the same name should be applied to the same cloud by all observers; and also that the existing names should be retained, only that the form they are applied to should be more precisely defined.

At Prof. Hildebrandsson's suggestion we examined the nomenclature used by different offices, and arranged the names systematically as given fully in Prof. Hildebrandsson's paper, "Remarks concerning the Nomenclature of Clouds for ordinary use" (p. 148), and we found that the differences did not seem irreconcileable.

Eventually, we agreed that ten terms, all compounded of Howard's four fundamental types—*Cirrus*, *Stratus*, *Cumulus*, *Nimbus*,—would fully meet the requirements of practical meteorology, with the least disturbance of existing systems; and we now offer this nomenclature for the consideration of meteorologists.

Prof. Hildebrandsson's views are fully set forth in his paper just quoted; I detail my own in the present communication. It must, however, be distinctly understood that while the Professor and I are in complete agreement as to the ten principal varieties of clouds—printed in capital letters in this paper—I am alone responsible for the names and definitions of the minor varieties, which for want of time I could not discuss with the Professor. We are both agreed as to the names which should be applied to the ten varieties of clouds whose photographs are reproduced in this paper. The examples are intentionally selected from all parts of the world, so as to show the truly International character of the nomenclature which they propose.

The problem of an International nomenclature is very complex, for all the following considerations must be fully weighed.

The varieties of clouds are very numerous, though there are only four principal kinds. All are interesting from a scientific point of view, but only a few can be used practically by seamen and others. The four great kinds of clouds are reproduced in endless modifications, so that only typical varieties can be given, for one may merge insensibly into the other, and the observer is often puzzled to tell which type a certain cloud most nearly approaches.

The terms of Howard's nomenclature are in use all over the world; but the same name is not applied to the same cloud in different countries. For this reason the names of the principal varieties are restricted to variations of Howard's four fundamental kinds, *cirrus*, *stratus*, *cumulus* and *nimbus;* though I have adopted some of Ley's new names for other interesting varieties. For the same reason, though we believe Ley's distinction between *cirro-velum* and *cirro-nebula* (as will be explained further on) to be really valuable;—since the term *cirro-stratus* is already in use for almost the same cloud, we do not think that the advantage to be gained by adopting the new terms would counterbalance the objections to a totally new name.

A new consideration has now to be taken into account in naming clouds, and one which was scarcely thought of in Howard's day, viz. the relative altitude. This is so clearly explained in Prof. Hildebrandsson's paper (p. 148) that the reasons need not be repeated here; suffice it to say that it is necessary to have *Cirro-cumulus* and *Cumulo-cirrus* for the high and low forms of the same fleecy cloud; or else fallacious results would be obtained when the direction of the high and middle clouds are connected with the shape of isobars in which they were formed.

Since cloud forms are the same all over the world, they must be classified by form, and not by their relation to cyclones, anticyclones, &c. for the same forms are seen on the Equator as in the cyclone—traversed regions of the North and South Temperate Zones. A circulating and condensing moist atmosphere can only develop certain forms; and it does not matter whether an ascensional movement is caused by the direct heat of the sun at the Equator, or by the uptake of a cyclonic vortex on the Arctic Circle.

The nomenclature is not strictly etymological, but, as far as possible, *Cirro* is applied to hairy structure, *Strato* to flat sheets, and *Cumulo* to rounded or rocky forms. But at the same time, *Cirro* is partly used to denote height; and *Cumulo* or *Strato* a lower level, as being practically both lower and denser. Hence a high fleecy cloud is called *Cirro-cumulus*, a lower species of the same kind—probably a little denser—is called *Cumulo-cirrus*. The first word of a compound indicates the height, *e.g. Cirro-stratus* is higher than *Strato-cirrus*.

It has been suggested by Capt. H. Toynbee that descriptive epithets should be used to simple names, thus—high *Cirro-cumulus;* low, or dense *Cirro-cumulus*, &c.; but though no doubt such a system is really the best for sailors, many Meteorological Directors prefer Latin words for International use, especially for the abbreviations, such as *Cr.-cm.* or *Cm.-cr.* for *Cirro-cumulus* and *Cumulo-cirrus* respectively.

I think that it is better not to complicate cloud nomenclature with any idea of origin, for the same form is often reproduced under very different conditions; but it is very desirable to group different varieties approximately for height. I have therefore divided all my varieties of clouds into three levels,—high, middle and low. This holds for practical purposes all over the world. The Upsala measures of cloud heights show that there clouds have a most decided tendency to form at certain levels. The actual levels will of course vary with the season and the latitude; but in the Tropics I have also constantly observed the tendency of clouds to form at three levels:—a high level of pure wispy *Cirrus;* a middle layer of flat *Cumulo-cirrus* and *Strato-cirrus;* and a lowest layer of *Cumulus,* or *Stratus* cloud.

But there is another reason for giving preference to certain characteristic varieties, in that they are not only more frequent, but also more persistent. For instance, *Strato-Cumulus* is observed from the Equator to Spitzbergen, and persists for hours together; while the festooned or pendulous forms of *Cumulus* and *Stratus* are common in the Tropics, rare in England, and unknown in Sweden; but rarely in any country last more than ten or fifteen minutes.

In the following table of cloud forms, the ten principal varieties on which I am agreed with Professor Hildebrandsson are printed in capital letters; but all the varieties are grouped together so as to show their relation one to another. The photographic illustrations are intentionally selected from various parts of the world, temperate as well as tropical, north and south of the equator.

VARIETIES OF CLOUDS.

HIGH.

CIRRUS. Hairy curl cloud.
CIRRO-STRATUS.
Cirro-Nebula. Cirrus haze.
Cirro-Filum. Cirrus stripes.
CIRRO-CUMULUS. Fleecy cloud.

MIDDLE.

STRATO-CIRRUS.
CUMULO-CIRRUS. Low fleecy cloud.
Festooned Cumulo-cirrus.
Mackerel sky.

LOW.

CUMULUS. Rocky cloud.
Mammato-Cumulus. Festooned Cumulus. Turreted Cumulus. High Cumulus.
STRATUS.
Festooned Stratus.
STRATO-CUMULUS.
NIMBUS.
CUMULO-NIMBUS.
Cumulo-Stratus.

A short description of each of these varieties will now be given. Of course there are really many more varieties of cloud which can be distinguished by specialists in cloud forms, but it would be inexpedient to discuss them in this Paper. I have only introduced some here to show more clearly the ten forms proposed for International use, by explaining both what they are and what they are not.

HIGH CLOUDS.

CIRRUS in its pure and simplest form is a wisp of hairy or feathery cloud. As such the word is universally used. Fig. 1 (Plate III.) is a photograph of a cirrus wisp in front of a cyclone near London. The cloud looks dark against a bright sky, instead of white against a dark background, as the picture was taken at sunset. Cirrus is not very common in the Trades and near the Equator, but very frequent in higher latitudes.

CIRRO-STRATUS is a thin veil of wispy cloud, flatter than pure cirrus, and usually more or less mixed with a light formless haze of ice dust. The varieties are infinite, and great discrepancies exist among various observers. For instance, Dr. Hildebrandsson scarcely considers a cloud cirro-stratus as long as any blue can be seen between the threads of cirrus; but others would consider an obvious layer of wispy cirrus, with blue between, as cirro-stratus and not as pure cirrus. Hildebrandsson's discovery, that cirro-stratus is often higher than pure cirrus, is both interesting and important. This is a very difficult cloud to photograph. Fig. 2 (Plate III.) is, however, a fairly good representation of a reticulated cirro-stratus, taken by me near Dover in England. This reticulated form is almost unknown in the Tropics, but very common in higher latitudes.

Cirro-Nebula (Cirrus haze). This variety was first suggested by the Rev. W. Clement Ley, to denote the characteristic, formless haze of ice dust at a high level which precedes cyclones, and some kinds of thunderstorms. I consider this a most valuable contribution to cloud names, and think the word should be universally adopted for the higher class of observations. It occurs all over the world.

Cirro-filum. Cirrus stripes. This is another variety of cloud, also first classified by Ley. It refers to the stripes, striated or otherwise, into which cirrus often ranges itself. These lines are important for weather prognostication in temperate regions, but are seldom seen in the Tropics. I think that even moderately good observers might be trained to note and record the direction of any allinement they might see in cirrus or cirro-stratus, without being hampered by another name for this variety of cloud.

CIRRO-CUMULUS. Fleecy clouds. This is a thin high cloud, more or less in detached masses, with a characteristic structure like lamb's wool. It occurs all over the world, and is common in all latitudes. Fig. 3 is a photograph of a characteristic specimen taken by me near Dover, England.

MIDDLE LEVEL CLOUDS.

STRATO-CIRRUS.—This is simply a denser and lower form of Cirro-stratus, but the word Strato is put first to give the idea of being lower than Cirro-stratus. This cloud is unknown at Upsala, but very common in the Tropics, and by no means rare in England. A tropical example has therefore been selected in Fig. 4, which represents only a moderately typical Strato-cirrus cloud in the North-west Monsoon of the Indian Ocean, lat. 5° S., long. 89° E. The cirriform structure can be easily recognised, but the cloud is approximating to Strato-cumulus.

CUMULO-CIRRUS.—Fleecy cloud. This in form alone is identical with the before-mentioned Cirro-cumulus; only a little denser and thicker, and above all at a lower level. It is introduced simply as an easy way of expressing low cirro-cumulus, but putting the word *cumulo* first. This is the cloud designated as *Alto-cumulus* at Upsala. The illustration, Fig. 5, is from a photograph by me in the vicinity of the Falkland Islands. The structure does not come out very well in the reproduction.

"Mackerel Sky" may be either Cirro-cumulus or Cumulo-cirrus, but the detached masses, though flat, have not the characteristic fleecy structure of Cirro-cumulus. For the present I do not attempt to put a new international name on this form of cloud; though it would be partially covered by the *Cirro-granum* of Ley. This is a very rare cloud, if the term is restricted to small, non-fleecy patches of cloud.

"Festooned Cumulo-cirrus" is a dense form of Cumulo-cirrus in which the component nubecules, though at a middle level, are so heavy as to droop, and present a base rounded downwards. This form is unknown in Sweden; but when in the Tropics they catch the reflection of a purple after-glow, and appear to hang like pink grapes in a transparent sky, they are among the most beautiful of clouds.

LOW LEVEL CLOUDS.

STRATO-CUMULUS.—This is another cloud form to which a variety of names are applied by different observers. I think it should be applied to a low-level cloud, too lumpy to be called pure stratus, but not composed of the rounded flat based masses of true cumulus. This cloud is found all over the world. Sometimes in the Tropics the masses of cloud are so arranged, that when seen in perspective near the horizon they look like parallel bars of cloud. This is the kind to which the term Roll-cumulus has been applied by the British Meteorological Office. (For further details see the Paper by the author "On the form of cloud to which the name Roll-cumulus has been applied," p. 147). The illustration (Fig. 6) was taken by me in the North-east Trade, not far from the Peak of Teneriffe.

CUMULUS.—Rocky cloud. This in its pure form is a detached cloud, with a flat base and a rocky top, and may vary from a small nubecule to a mountainous mass. The picture, Fig. 7, was taken in the South-east Trade, about 100 miles from Santos on the Brazilian coast. This is one of the commonest clouds everywhere, but becomes less frequent the further we proceed Polewards. It is, however, known even in Spitzbergen.

Turretted Cumulus, Linear Cumulus, or High Cumulus. All these names have been applied to a long line of high-level, small Cumulus heads; a very beautiful and characteristic cloud before some classes of thunderstorms. They are practically unknown in Sweden, and are not common in England. For the present I shall not attempt to coin a new word for this cloud; but I think that Ley has somewhere proposed the very suitable word *Cumulo-pileatus.*

Mammato-cumulus. Festooned cumulus. This is a cumulus whose base hangs down in festoons. It is unknown in Sweden, tolerably common in Great Britain under the popular names of "Pocky cloud" or rain balls; and very common in the Tropics. Ley's word, "*Mammato-Cumulus,*" seems very suitable.

STRATUS. This is a word which is used in a most promiscuous manner by different observers for all sorts of low-level clouds. Some call it pure fog, a name unfortunately suggested by Howard's picture; others to fog when it has lifted off the ground; others to a low sheet of thin flat uniform cloud. The forms are really so various, that probably the two latter, which are often indistinguishable, should be called typical stratus.

The illustration Fig. 10 is that of a very low level sheet cloud in London, exceedingly typical of an East wind in that City.

Stratus occurs all over the world, but is more common out of the Tropics than near the Equator.

Festooned Stratus. This is similar in character to pendulous cumulus. The flat under side of a sheet cloud droops into small festoons. It is very transient, and unknown in high latitudes.

NIMBUS.—This is also a kind of cloud about which observers differ very much. Theoretically every cloud from which rain falls should be called *Nimbus;* but in practice all over the world rain falls from two distinct types of cloud—from a stratiform cloud, something like that which has just been called *Strato-cumulus;* and from a mountainous *Cumulus.* The former is characteristic of extra-Tropical cyclone fronts; while the latter is distinctive of thunderstorms, the bulk of rain in the Tropics, and the whole of that on the Equator and in the Doldrums. The author thinks the word Nimbus should be restricted to rain from stratiform clouds, and to all the class of clouds known as scud, raggy cloud, *Fracto-cumulus, Diablotons, Fuyards,* &c., which are formed under a dark canopy of rain cloud, even when it is not possible to see whether the summit of the cloud is flat or rocky. The illustration (Fig. 9) is that of a rain cloud in London with patches of dark raggy cloud floating under a lighter grey mass of cloud.

CUMULO-NIMBUS. I think that this term should be restricted to the mountainous cumulus which discharges rain in showers and thunderstorms. The word has many advantages. In the first place, as just described, it practically defines the nature of the rain,—whether cyclonic or not; and secondly, it practically separates the cumulus of a fine day from the similar cloud of a showery day. Of course one form often grows into the other, but still the distinction can often be made in practice. This cloud has often been called *cumulo-stratus;* but for reasons which will be detailed below, I think that term should be relegated to a particular variety of *cumulo-nimbus.* The illustration, Fig. 8, is a typical tropical cumulo-nimbus hanging nearly over the city of Rio Janeiro.

Cumulo-stratus.—Sometimes a flat stripe is seen crossing a *Cumulo-nimbus*, or the top of that cloud seems to stretch out flat as if a stream of air impinged against a flat wall, till the whole looks like a mushroom; or else a peculiar hazy slightly hairy layer of cloud seems to form on the top of the *cumulo-nimbus*. How far these appearances are simply the effect of one cloud seen in perspective against another, or how far they are a development of the cumulus itself, need not be considered here. Suffice it to say, that the appearance is a well-known associate of showers and thunderstorms from the Doldrums to Scandinavia; and that though the name is decidedly unfortunate, it is so widely used, that in my opinion the appellation should be retained for scientific meteorologists, but not retained among the cloud names of the first rank, for general use.

Explanation of the illustrations of the ten principal varieties of clouds, proposed by M.M. Hildebrandsson and Abercromby for International use.

		High Clouds.	
Fig.	1.	Cirrus. Curl cloud.	England.
,,	2.	Cirro-stratus.	England.
,,	3.	Cirro-cumulus.	England.
		Middle Clouds.	
,,	4.	Strato-cirrus.	Indian Ocean, lat. 5° S, long. 89° E.
,,	5.	Cumulo-cirrus.	Falkland Islands.
		Low Clouds.	
,,	6.	Strato-cumulus.	North-east Trade, near Teneriffe.
,,	7.	Cumulus.	South-east Trades, lat. 28°S, long. 45°W.
,,	8.	Cumulo-nimbus.	Rio Janeiro.
,,	9.	Nimbus.	London.
,,	10.	Stratus.	London.

I am indebted to the Council of the Meteorological Office for the loan of the negatives from which Figs. 2, 3, 9, and 10 have been reproduced. The whole of the photographs were taken by me, and have been reproduced by a collotype process, half the original size linear, by the Autotype Company of London.

Note added June 1887.

In the discussion on this paper exception was taken to the application of the words *cirrus* or *cirro* to middle level clouds; and the desire expressed that those words should be restricted to the highest level only.

For a strict nomenclature by form alone, *cirrus* or *cirro* should be applied to every cloud with a fibrous or hairy structure, independent of height; *strato* to everything flat or in thin layers; *cumulo* to everything rocky or in lumpy masses.

Now we must face the facts that cirriform clouds may form on the top or at the sides of cumulo-nimbus or low rain cloud, as well as at both middle and highest levels; that stratiforms are developed at all levels, from the lowest radiation stratus to the highest cirro-stratus; and cumuloforms at both the lowest and middle levels. We must also note that the compounds, which we have called cirro-cumulus and cirro-stratus, are found at two such different mean levels as 12,000 and 20,000 feet; though the only difference in form is that the lower level clouds are rather denser and more shadow-producing than the higher ones.

The words *cirrus* and *cirro* have—we think unfortunately—come to be associated too much in many minds with the idea of height alone, to the exclusion of the characteristic hairy structure. For instance, in the variety called *cirro-nebula* there is no structure of any kind, but a formless haze is developed at a very high level, and the word *cirro* simply denotes altitude without reference to form. Some meteorologists refuse to apply the prefix *cirro* to any fibrous cloud except at the highest level, and hence the confusion of names.

Too much importance has, we also think, been attached to the composition of clouds, whether made up of ice or water particles. No doubt high level cirrus is usually frozen; but the lowest stratus and cumulus are often composed of snow, without in any way losing their characteristic shape.

The nomenclature proposed in this paper was the outcome of an attempt to arrive at a practical but illogical compromise of existing names and ideas, by using the prefix *cirro* partly as descriptive of structure, partly as indicative of level.

The advocates of the system in which *cirro* only denotes height must be prepared with an entirely new name for the clouds we call cumulo-cirrus and strato-cirrus, which do not differ, except in height, from cirro-cumulus and cirro-stratus. If a term is wanted to denote height, *alto* would be much better both physically and philologically.

But if meteorologists were prepared to accept the broad principle that the name of a cloud should be given by form alone, and the idea of height by an adjective—high, middle, low; alto, medio, basso—then a far more logical system could be elaborated. We should be able to use the prefix *cirro* for fibrous or hairy clouds at any level, and the nomenclature would be much simplified. If an observer was in doubt as to the height, he could anyhow record the form correctly, and the system would facilitate observations on the motion of clouds at the three principal levels.

An objection has also been made to our proposed nomenclature, that there is no word for a completely uniformly overcast sky, and the words *velum* (veil), or *pallium* (cloak), have been suggested to remedy this omission. We think, however, that any such term would be most deceptive. The sky may be uniformly overcast, either under a thick layer of low stratus in fine weather, or under any of the forms of cloud that are just verging on the precipitation of rain. The name must be judged by the surroundings, and the first should be denoted by stratus, the latter by nimbus. In some cases it would be expedient to record—overcast—without attempting to put a name on the cloud.

DISCUSSION.

Mr. CANN-LIPPINCOTT sent the following translation from *Goethe's Meteorology*, which was read by the Secretary:—"These four principal definitions, Cirrus, Cumulus, Stratus and Nimbus, I have retained unaltered, convinced that in scientific matters in general a decided laconic terminology, by which objects are stamped, proves of the greatest advantage; for just as a proper name separates the man from every other, so do such *termini technici* separate that which is designated by them from everything else. If they have been once found to be good, they should be accepted in all languages; they should not be translated, because in that way the first intention of the inventor and founder of them is destroyed, for his intention was to make something and to complete it. If I hear the term *stratus* I know that the conversation is about the scientific modification of clouds, and we talk of this with those only who know something of the subject. In the same way, by retaining such a terminology the intercourse with foreign nations is rendered more easy. Let it also be considered that by this patriotic purism of style nothing is gained; for since it is known, as it is, that in such treatises clouds only are being discussed, it does not sound well to speak of 'Heap Clouds,' &c. and to keep repeating the general when speaking of the particular. In other scientific descriptions this is expressly forbidden."

Mr. DYASON said that the Society was much indebted to the authors of these Papers for their contribution to our limited knowledge of the clouds, but he wished to put in a plea for the study of the chromatics of the sky, in addition to form, motion and height. Mr. Abercromby appeared to struggle against his own convictions in not making marked reference to colour. The only words on colour in the first Paper were "blue," "paleness about the colouring," and the "blueness of the sky has begun to sicken and grow pale"; but he also said, "This Paper is to expound the general principles by which we must read cloud-forms so as to deduce useful indications from them as to the future weather; . . . . but again, weather prognosticated by any particular shape is not the same." Why should he ignore colour in these paragraphs? What does the author mean by the sentence, "These examples illustrate the general principle of interpreting cloud-forms by their surroundings," and prove that shape alone is not sufficient to give a true prognostic value? "Clouds always tell a true story, but one which is difficult to read." Mr. Abercromby would no doubt not deny that colour is a part of the true story, although it may be difficult for him to read. In the second Paper Mr. Abercromby says, "Photographs are infinitely better than drawings or engravings; it must be borne in mind that both colour and distance are lost in photography, though the form is accurately reproduced." Form is only approximately given in photography, as in drawings. Cloud-forms are not stationary, even for the centesimal part of a second. He (Mr. Dyason) deeply sympathised with the author in his ten years' hunt for "suitable pictures or photographs of clouds from every possible source without success." Further, he presumed that the author meant after capture "the pictures were usually pretty" (clouds always are pretty), "but wanted point meteorologically." He had always thought correct readings by standard instruments at the time of the observations gave point meteorologically. The author says, "The difficulties of cloud photography are numerous," but are the attempts at coloured drawings of clouds to be ignored on that account? The eye and hand of the expert are wanted in both cases. The author also says, "that when the 'festooned cumulo-cirrus' in the tropics catch the reflection of a purple afterglow, and appear to hang like pink grapes in a transparent sky, they are among the most beautiful of clouds;" and yet, forsooth, he ignores all through his Paper the factor of colour. With deference he (Mr. Dyason) asked, Is not every plane of visible vapour floating through the air an object for spectroscopic study as an aid to forecasting?

In speaking of clouds it might be said that the form is their anatomy, and the colour or chromatics their physiology. As in the worlds of animal and vegetable life the duty or function of every organ can always be prognosed by a knowledge of both worlds, so in cloud-land should form and colour be jointly studied. By pursuing this course he ventured to think the day was probably not far off when forecasts of weather would have a higher percentage of correctness than at present, if the reporters would only note the colour of the sky.

Mr. **ARCHIBALD** said that neither Dr. Hildebrandsson nor Mr. Abercromby had made any mention of Professor Poey's pictures of cloud-forms given in his book on clouds. Perhaps the authors had not noticed this work, which he considered the most complete hitherto extant. Both of the papers were, he thought, excellent, and he was glad that the height of clouds had been recognised in the classification suggested by Messrs. Hildebrandsson and Abercromby. Altitude of clouds was a very important feature, and one which should certainly be noted in connection with their classification. He hardly considered that the term stratus was sufficient to denote all clouds below an altitude of 3,000 metres. When conducting kite-flying experiments at Tunbridge Wells, he had frequently seen stratus, or what would be called stratus, driving along at an elevation of only 200 or 300 feet above the ground. He had proved this by measurements made with a theodolite. This cloud, which only occurred in certain weather, is very thin, and drifts along like fog. Scud might perhaps be a good name to distinguish this variety.

Dr. **TRIPE** agreed with Mr. Archibald that the height of clouds should be observed. Dr. Hildebrandsson gave the height of the highest clouds as 9,000 metres, or about 5 miles, whereas the majority of text-books on meteorology gave the altitude of cirrus as 7 or 8 miles. Possibly, however, the figures given in the text-books were the result of guess work, and as Mr. Abercromby, having seen cloud measurements made at Upsala, was satisfied as to the accuracy of these measurements, Dr. Hildebrandsson's figures were probably more correct. It was very often a difficult matter to make accurate observations of cloud-forms, especially with some varieties. He had frequently seen cumulo-stratus, and was very much struck with the formation of this cloud; it being by no means easy for an untrained eye to determine whether a cloud of this description was hard stratus or not. No person who was not well acquainted with the motion of higher clouds could hope to prognosticate weather changes. He had frequently observed instances in which alterations in weather could be foretold two or three days beforehand by means of the movements of the upper clouds.

Mr. **RUSSELL** said he was glad that the subject of cloud nomenclature was being placed on a right footing, and he thought the classification suggested by the authors of these Papers would be ultimately adopted. The comparatively low height given by Dr. Hildebrandsson for high clouds in Sweden might perhaps be due to the difference in latitude between London and Upsala. He thought festooned cumulus hardly required separate mention as a variety, except, perhaps, on account of its value as a prognostic. There was another species of cumulus with flat overlapping segments which preceded fine dry weather and accompanied Northerly winds. There were also many varieties of cirrus of distinct value in forecasting. Dr. Hildebrandsson stated he had seen cirro-stratus higher than cirrus. He (Mr. Russell) had seen both cirro-stratus and cirro-cumulus at a higher level than cirrus on rare occasions, once in September 1883. There seemed to him to be an objection to the use of the term cumulo-cirrus, as the cirrus compound had been confined to forms of high clouds, into which cirrus frequently passed. Regarding turreted cumulus, which had been stated to appear before thunderstorms in summer, the photograph and description led him to compare it with a cloud he had taken to be a kind of cirro-stratus, which appeared sometimes before gales in autumn and winter. It might owe its development to some electrical action.

Capt. **WILSON-BARKER** said there was one point in which he differed from Mr. Abercromby. It seemed to him that the cirrus cloud is very distinctive of the weather before and after cyclonic disturbances, and the distinctions hold good everywhere. A cloud not represented in the photographs is a form of cumulus which rises from a base of comparatively small area to a great height in the atmosphere, and remains for long periods stationary. This cloud is common in the calms North and South of the Trade Wind regions in both hemispheres. He had never seen it in the vicinity of land. There was another type of cumulus to be seen in the belt of rains from which heavy showers fall, but it displays no cirriform tops. Mr. Abercromby had shown a picture of a small cumulus, which he thought belonged to a form that always precedes electrical disturbances. Two classifications appeared to be very necessary—(1) a simple classification, even more simple than those proposed, based on the simplest distinctions; and (2) a more complex classification for scientific observers.

Mr. WHIPPLE said that in instructing and training observers at the Kew Observatory ten forms of cloud were usually adopted, and he had found it easy to get beginners to readily distinguish these varieties. He then gave the list of cloud names formerly used at Kew,[1] and said observers would do very well under ordinary circumstances with the list he had just given, and he feared there would be some difficulty in getting some of the terms suggested in the Papers to be understood. He corroborated Dr. Tripe's remark that cirrus in this country lies considerably higher than 9,000 metres. He considered it was impossible to satisfactorily determine the height of clouds by mere visual estimation.

Mr. GASTER was glad to hope that meteorologists were beginning to approach a more rational method of observing clouds than that hitherto prevalent. Luke Howard, after defining very clearly the characteristics of certain forms, and speaking of the necessity for not deciding their names by their form alone, confused at once the clouds of the *cirrus* type with those of a lower level, and from that time to the present there had been endless confusion in the minds of observers as to the nature of all the higher clouds which they were observing. It should be remembered that there are at least four points to be considered in classifying clouds—(1) Form; (2) composition; (3) height; and (4) movement. Clouds of the highest (*cirrus*) type are distinguished from other clouds in all these points. These peculiarities they acquired simply from their height, and as "cirrus is the highest form of cloud," he deemed it necessary to apply the term *cirrus*, or the corresponding prefix or affix, to clouds of this type only. He offered himself to communicate a Paper on the subject shortly.

Mr. ARCHIBALD remarked that single observations of cirrus by M. Ekholm showed a much greater altitude than 9,000 metres, this measurement being the mean of many observations.

Mr. ABERCROMBY, in reply, said it would be a very difficult matter to introduce colour into a cloud classification, although so far as regarded sunrises and sunsets colour was certainly very important in connection with weather prognostics. In the tropics, particularly, sunsets were a great aid in forecasting, as changes in the weather were indicated by them before the barometer showed any signs of the approaching alteration. It was very desirable to secure accurate illustrations of typical cloud-forms at a moderate cost, and reproduction by photography seemed to be the only means by which this could be satisfactorily accomplished so far as accuracy was concerned, although the question of its cost was an important consideration. Wood engravings frequently failed to give a true representation of cloud-forms, as the engraver was unable to correctly reproduce tint and texture. Dr. Hildebrandsson and he had consulted Poey's book, but while in some particulars it was good, in many points it was so manifestly wrong that they resolved to discard it altogether. With regard to stratus clouds, he said he had found their classification a very difficult matter, and if it was desired to keep the lower variety distinct from the higher, he suggested that the term Stratus should be kept to the higher levels, and the lower cloud be named Pallium. The height of 9,000 metres for cirrus cloud given by Dr. Hildebrandsson was a mean height, the extremes observed being much higher. He referred to the effect of latitude on the height of clouds, remarking that Upsala was the only place where really good observations of cloud altitude had ever been made. He then briefly remarked upon Prof. Piazzi Smyth's observations of cloud heights at Teneriffe, and stated in reply to Mr. Whipple that the thickness of a cloud generally gave some idea of its probable height. Referring to Capt. Wilson Barker's remarks, cirrus as a class of cloud often forms during fine weather both in and out of the tropics; but that particular form commonly known as "cat's tails" seemed to be particularly characteristic of hurricanes. The variety of cumulus, which rises from a small base to a great height, is very characteristic of the calms of Capricorn and Cancer, but does not require a special name. Mr. Gaster had hit exactly the great difficulty in naming clouds, by calling attention to the use of the words *cirrus* or *cirro* for clouds at middle level; but he (Mr. Abercromby) could not agree with all his remarks. Composition, whether of water or ice, was no criterion of cloud-form, as the lowest cumulus and stratus were often composed of snow. We must face the fact that forms of cirro-cumulus and cirro-stratus are formed at such different mean levels as 12,000 and 20,000 feet; and if *cirrus* and *cirro* are only to be applied to the highest clouds, we should have to give separate names to two similar forms.

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[1] 1. Cirrus. 2. Cirro-stratus. 3. Cirrus haze. 4. Cirro-cumulus. 5. Cumulus. 6. Detached Cumulus. 7. Stratus. 8. Nimbus. 9. Uniform Mass. 10. Scud.

THE
Influence of Weather on the proportion of Carbonic Acid in the Air of Plains and Mountains.

By William Marcet, M.D., F.R.S., F.R.Met.Soc., and Auguste Landriset, Chemical Assistant at the University of Geneva, &c.

[Read February 16th, 1887.]

Ten thousand parts of air contain in round numbers 2,100 parts of oxygen and 7,900 of nitrogen, together with a proportion of carbonic acid varying from a minimum of under three parts, to a maximum which may rise to about fourteen parts in towns under certain conditions of the weather, but in general an approximate mean of four parts in 10,000 is adopted. It is interesting to observe that these figures show the exact balance between growth and decay, the carbonic acid of the air supplying carbon for the nutrition of plants, and the atmospheric oxygen being the destructive agent, under whose influence the carbon from decomposing organic matter returns into carbonic acid. It is hardly derogatory to say that man and animals have had to accommodate themselves to the composition of the atmosphere in which their existence is maintained.

In addition to oxygen, nitrogen, and carbonic acid, the air contains moisture varying in tension approximately from 0·181 in. at 32° to 0·868 in. at 75°; the history of atmospheric moisture belongs to the science of meteorology, inasmuch as it varies in its proportions under the influence of the weather. It has been shown within the last few years that the weather has also an intimate connection with the proportion of carbonic acid in the atmosphere, a fact Dr. Russell has clearly brought to light, and which is shown on the chart now exhibited on the wall. It will be seen that in foggy weather, in London, the carbonic acid undergoes a marked increase, and its proportion of, say four parts in 10,000, has been found to rise in the air near St. Bartholomew's hospital, during a thick fog, to as much as fourteen parts, or over three times its proportion in fine weather.

It is obvious that at increasing altitudes above the sea, although the proportion of three or four parts in 10,000 may be maintained, nevertheless air must contain a smaller weight of the gas in a given volume, and that in proportion to its rarefaction; for instance, a cubic foot of air at the sea-level will be found to hold a greater "weight" of carbonic acid than a cubic foot of air at the summit of Snowdon, and the difference will be more or less in proportion to the barometric pressure.

At the summit of Mont Blanc, 15,760 ft. above the sea level, there can only be very little carbonic acid in a given volume of air. Its presence in such lofty regions was distinctly observed, however, by Horace Benedict de Saussure, in his memorable ascent of Mont Blanc. He relates in his book, entitled *Travels in the Alps*, published in the year 1796, how he placed on the top of Mont Blanc two small glass receivers containing mixtures of equal parts of water and lime water, and after a lapse of three quarters of an hour he observed that a small pellicle had formed on the fluid; moreover having exposed to the air pieces of paper wetted with a solution of potassium hydrate, he found that a marked effervescence took place when these were subjected to acids; these two experiments showing clearly the presence of carbonic acid.

Theodore de Saussure, the son of Horace Benedict, undertook at Geneva an extensive series of investigations, which was published in 1828, in order to find out whether the proportion of carbonic acid in mountain air differed from its proportion in the plains, and he concluded that mountain air contained a greater proportion of that gas than the air of the plains or valleys. This, the author observes, can be explained from the decomposition of carbonic acid gas taking place mainly in the inferior layers of the atmosphere where vegetation is most active, and from the more ready absorption of the gas by the soil of the plains, where the surface-water is slower in disappearing than in the mountains.

These results were generally accepted, and it was acknowledged that there was proportionally more carbonic acid on mountains than in the plains.

However, in 1878, M. P. Trochut[1] obtained conclusions from similar experiments the reverse of those of de Saussure, and his method of analysis was certainly more correct. He examined the air at Clermont Ferrand (1,295 feet), at the summit of the Puy de Dome (4,749 feet), and at the top of Pic de Saucy (6,174 feet), and found respectively at these various altitudes 3·13 parts, 2·03 parts and 1·72 parts of carbonic acid in 10,000 of air, from which he concluded that the amount of carbonic acid falls somewhat rapidly in relation to altitude. Such different results showed obviously that we possessed no reliable knowledge as to the effects of altitude on the proportion of the atmospheric carbonic acid; and one of us, Dr. Marcet, who had been engaged for many years on an inquiry into the influence of altitude on the chemical phenomena of respiration, proposed to take up this subject. As the investigation necessitated the presence of two observers, one on the mountain station and the other in the plain or valley, both experimenting as nearly as possible at the same time, M. A. Landriset, of Geneva, an experienced chemist, joined in the work.

We had both acquired separately great experience in the mode of determination of carbonic acid known as Pettenkofer's method, which is exceedingly delicate, and admirably fitted towards the object we had in view. The process need not be described on the present occasion; as to its accuracy, it may be observed that each of us having analysed the air on the same spot and at the same moment, one found in 10,000 parts of air 3·596 parts of carbonic acid, and the other 3·610 parts, the difference amounting to only 0·4 per cent., which is quite inappreciable. Thus we felt assured we could rely on the concordance of our analyses.

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[1] *Comptes Rendus de l'Acad.* 1878.

We selected two stations, one near the Lake of Geneva, about 90 or 100 ft. above the lake, and very nearly 1,300 ft. above the sea level; the other at the summit of "The Dole," the highest point of the Jura chain, at an altitude of 5,493 ft., giving a difference of altitude of 4,193 ft. This station was convenient in many respects, a high road allowing of the instruments being conveyed in a carriage to a distance of 2½ hours' walk from the summit of the mountain. Moreover, it could be distinctly seen from the low station; and indeed there was no difficulty in clear weather in following with a telescope the movements of the observer stationed on the mountain top, at a distance of 11 miles measured on the map. We had arranged to note the weather, barometer and dry and wet bulbs at the moment of every experiment; a Fortin barometer was carried up to "The Dole," while the barometric readings at the Geneva Observatory were used for the lower station, the altitude being nearly the same. In every analysis the result obtained was reduced to dry volume, sea-level pressure and freezing point. The diagram shows at a glance the nature of the work and results obtained.

On August 31st, 1885, a first series of experiments was undertaken on the mountain-top and in the valley. In the morning from the low station it was impossible to see any thing of the chain of the Jura, which was screened by thick clouds, but by degrees the weather brightened, and about noon cleared up with a light Northerly breeze. At 3.50 p.m. the summit of the Dole was seen alternately in and out of the cloud, at 5.45 the Jura was very nearly uncovered. On the summit of the Dole that same day at 11 a.m. the observer, according to his own notes, was in the cloud, with a moderate North-east wind. At 11.45 the cloud was lifting and the sun shone, but by 1 p.m. the cloud had formed afresh, 2 p.m. the cloud was lighter, 3 p.m. the weather had cleared up.

The analyses of the air, which amounted to six in number at each station, showed distinctly that the proportion of carbonic acid on the mountain fell in the cloud and increased as the weather cleared up; thus the mean of three experiments in the cloud at the high station gave 3·24, and the mean of the three other experiments at the same station made in clear weather gave 3·84 parts in 10,000—an increase of 10 per cent. in clear weather. In the Valley, near Geneva, where there was absolutely no cloud, the weather being fine nearly the whole day, the mean atmospheric carbonic acid amounted to 3·88 per 10,000 of air; and it is interesting to remark that the mean of the carbonic acid of the low station, where the weather was fine, is all but exactly the same as the mean of the three experiments made at the Dole that same day in clear weather. Another fact worth recording is, that at 11 a.m. the observer on the mountain top while in the cloud only found 2·94 parts of carbonic acid in 10,000 of air, while at 11.45, the cloud having temporarily lifted and the sun shining, the proportion of this gas rose to 3·91, or by 25 per cent. The cloud having returned, an experiment undertaken at 1 p.m. again showed a distinct falling off in the carbonic acid, the proportion obtained—3·08—being very nearly the same as that found in the first experiment before the cloud had lifted.

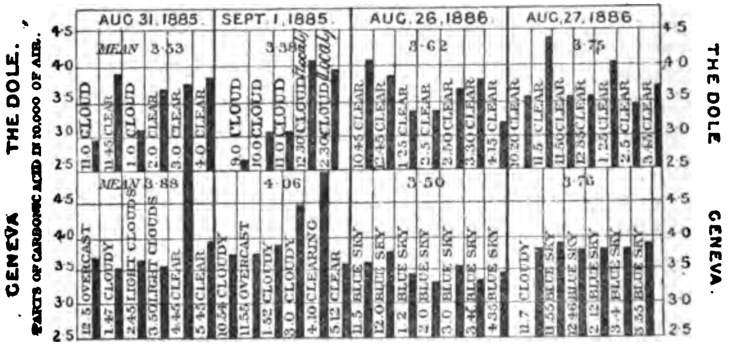
This first series of experiments appears to show that in clear weather the proportion of carbonic acid in air is precisely the same at an altitude of 5,493 feet on the Jura mountain, and at 1,300 feet in the plain near Geneva; while in cloud, on the mountain-top, the proportion of carbonic acid falls very materially below its figure for fine weather on the mountain and plain.

The experiments which follow yielded results agreeing remarkably with those reported above, an apparent discrepancy in two of them admitting of a ready and obvious explanation.

On September 1st, 1885, at the lower station the weather was clear and calm. In the morning until noon the sky was generally overcast, then the clouds dispersed in a light Northerly breeze; the day must be considered on the whole as fine. On the summit of the Dole, according to the notes of the observer at that station, at 9 a.m., a moderate North-east wind and cloud, at 10 a.m. cloud and rain, at 11 a.m. cloud continued, at 12.30 p.m. a thick cloud, and again a cloud is recorded at 2.30, indeed the cloud lasted while the experiments were being made; but it is important to bear in mind that according to the notes taken at the lower station, when the cloud was apparently thickest on the mountain, the same fog or cloud was seen from the plain to be absolutely local, just capping the summit where the work was carried on; perhaps a hundred yards on either side of the beacon, near which the observer stood, would have brought him into beautifully clear weather, and this limitation of the cloud continued from noon till 2.30 p.m., when the last experiment was made. The cloud was then obviously getting much thinner, as the beacon at the very top of the mountain could be seen from below with a good telescope, appearing and disappearing alternately as the fog lessened or became thicker.

Five experiments were made that day on the mountain and six in the valley. The analyses yielded a mean of 3·38 parts of carbonic acid per 10,000 of air at the high station in the cloud, and 4·09 in the plain where the air was clear and the weather on the whole fine, the excess for the "plain" amounting to 17·3 per cent. over the proportion found on the mountain in the cloud. It should be noted that in these experiments the carbonic acid at the Dole was observed to undergo a sudden rise in the afternoon to 4·49 and 4·96 per 10,000; the observer was still in the cloud, which, at 12.30, he recorded as "intense," little suspecting at the time that the cloud was hovering like a small mass of cumulus over the spot where he stood, together with the man who was helping him, and that fine clear weather was close at hand. Most certainly that day the sky continued from noon clearing up gradually at both stations, although the observer on the mountain was unconscious of it, and we found the carbonic acid at both stations to respond in a remarkable way to this improvement in the weather. On the Jura the carbonic acid at 9 a.m. in the cloud amounts only to 2·67 parts in 10,000, a very low proportion; it goes on increasing till 12.30 and 2.30 p.m., then reaching the figures of 4·11 and 3·98 per 10,000. In the valley a very similar phenomenon takes place, the proportion of carbonic acid found at 10.54 a.m. being 3·73 per 10,000, which proportion increases somewhat gradually to 4.49 at 3 p.m. and 4·96 at 4.10 p.m. There was probably some connection between the increasing proportions of carbonic acid in the plain and mountain summit as the day wore on, and it may be that a current of air charged with this gas and coming from a Northerly direction reached the mountain station about 12.30, or between 11 a.m. and that hour, and the station in the plain some time between 2 and 3. The Dole is about north-north-west of the low station, and the wind blowing is recorded as North at 5.12 p.m. at the lower station; indeed the weather cleared up in the afternoon with a light or very light Northerly breeze. There are, consequently, many ways of accounting for the increase of carbonic acid in the cloud that day on the mountain summit, and this phenomenon cannot be considered, in our opinion, as opposed to the results we have obtained.

INFLUENCE OF WEATHER ON THE PROPORTION OF CARBONIC ACID IN THE AIR
– GENEVA 1300 FT — THE DOLE 5493 FT ABOVE M.S.L.



On August 26th, 1886, the weather in the Geneva valley was very fine all day long, with a moderate North-north-east breeze. There was a slight haze in the atmosphere; a circumstance frequently observed while that wind is blowing, but only visible when distant hills or mountains are looked at; and this haze has apparently nothing in it of the nature of a fog, as the wind is usually dry.

On the Jura the weather was equally fine throughout that same day, at which station a strong North-easterly wind was reported. Seven experiments were made at each station. The mean carbonic acid found in the plain was 3·495 parts in 10,000, and for the mountain top 3·615. The difference between these two figures amounted only to 3·3 per cent., and is really insignificant; it can, therefore, be safely concluded that the proportion of carbonic acid in the atmosphere was the same at both stations, confirming in a remarkable way the results obtained in the preceding experiments.

The next day, August 27th, the fine weather continued at both stations, although the sky was somewhat cloudy in the plain before noon, after which time it cleared up; wind North-easterly moderate in the plain, Northerly strong on the mountain summit. No sign of clouds on the Jura. Again the experiments show similar results, and even more forcibly so. The conditions referring to the weather were precisely the same at each station on both days, and there was no great variation in the proportion of carbonic acid at either station respectively throughout the day.

Experimental Observations to determine the Amount of Proportion of Carbonic Acid in the Air.

Malagny (Geneva).			The Dole.		
Experiment.	Time.	Parts of Carbonic Acid in 10,000 of Air.	Experiment.	Time.	Parts of Carbonic Acid in 10,000 of Air.
1885, Aug. 31.					
1	12.5 p.m.	3·64	1	11.0 a.m.	2·94
2	1.47 „	3·57	2	11.45 „	3·91
3	2.45 „	3·64	3	1.0 p.m.	3·08
4	3.50 „	3·57	4	2.0 „	3·71
5	4.45 „	4·94	5	3.0 „	3·76
6	5.45 „	3·95	6	4.0 „	3·86
	Mean....	3·88		Mean....	3·53
1885, Sept. 1.					
1	10.54 a.m.	3·73	1	9.0 a.m.	2·67
2	11.55 „	3·76	2	10.0 „	3·07
3	1.52 p.m.	3·87	3	11.0 „	3·05
4	3.00 „	4·49	4	12.30 p.m.	4·11
5	4.10 „	4·96	5	2.30 „	3·98
6	5.12 „	3·57			
	Mean.. .	4·06		Mean....	3·38
1886, Aug. 26.					
1	11.5 a.m.	3·63	1	10.45 a.m.	4·04
2	12.0	3·79	2	12.45 p.m.	3·86
3	1.2 p.m.	3·44	3	1.25 „	3·38
4	2.0 „	3·25	4	2.5 „	3·38
5	3.0 „	3·54	5	2.50 „	3·67
6	3.46 „	3·35	6	3.30 „	3·82
7	4.35 „	3·46	7	4.15 „	3·16
	Mean....	3·50		Mean....	3·62
1886, Aug. 27.					
1	11.7 a.m.	3·73	1	10.20 a.m.	3·58
2	11.55 „	3·82	2	11.5 „	4·34
3	12.46 p.m.	3·73	3	11.50 „	3·58
4	2.12 „	3·73	4	12.35 p.m.	3·58
5	3.4 „	3·73	5	1.25 „	4·02
6	3.55 „	3·82	6	2.5 „	3·47
			7	3.45 „	3·69
		3·76			3·75

The mean of the seven experiments made on the summit of the Jura, and of the six made near Geneva in the plain, yielded all but absolutely the same figure, the mean proportion of carbonic acid for the mountain being 3·754, and for plain, 3·763 in 10,000 of air. The difference of 0·2 per cent. can be entirely neglected. Hence it is that on both these days, in settled fine weather, the mean amount of carbonic acid in the atmosphere was all but exactly the same on the mountain top and in the valley.

These experiments we must admit to be small in number, but they have been conducted with extreme care, and every precaution has been taken to avoid errors and ensure accuracy.

The results we have obtained are as follows :—

1. In fine clear weather on a mountain chain of a moderate Alpine altitude, and in the adjoining valley or plain, the atmosphere holds the same mean proportion of carbonic acid at both places.

2. When the summit of a mountain chain is in a cloud, a circumstance which frequently happens in an Alpine district, the air in the cloud contains a smaller proportion of carbonic acid than it would hold in fine clear weather; this result applying perhaps more fully when the mountain cloud is extensive in its area than when very local and circumscribed.

The similarity of the proportions of carbonic acid in the air of both high and low stations in fine weather admits of a ready explanation, as when the atmosphere is clear there is nothing to interfere with the free diffusion of carbonic acid throughout its area. On the other hand, a cloud on a mountain summit appears, from our experiments, to interfere with the diffusion of the carbonic acid arising from below, which must be the main region the gas is derived from. This view would be perfectly consistent with Dr. Russell's experiments on London air. He finds a considerable increase of carbonic acid during a fog; but in this case the gas does not come from below, but is generated on the spot, within the fog from the chimneys and inhabitants of the Metropolis, and it accumulates on the surface of the earth because its diffusion is apparently checked by the fog.

The present explanation still, however, remains incomplete, as it does not dispose of the carbonic acid which was on the mountain when the cloud arose, or when the moisture was condensed into cloud on the spot.

DISCUSSION.

Dr. W. J. **Russell**, F.R.S., said the paper appeared to demonstrate the point that the amount of carbonic acid in the air at the top of the mountain and down in the plain was, under ordinary conditions of weather, practically the same. He was surprised to see that there was so large an amount of carbonic acid present in the air of the neighbourhood of Geneva. With such large quantities as those occasionally found by Dr. Marcet, we should have a dense fog in London. The sudden rise and fall of the carbonic acid shown on the diagram was very remarkable; and the effect of the fog on the mountain in decreasing the amount of carbonic acid was also a most interesting point. These experiments raised several very important and interesting questions, and he hoped Dr. Marcet would continue his work on this subject.

Mr. J. **Ball**, F.R.S., said he considered Dr. Marcet's paper to be an important contribution to our knowledge of the distribution of carbonic acid in the atmosphere, but he did not think it established any positive conclusions. It had been shown, in various communications made to the Manchester Philosophical Society and other bodies by Dr. Angus Smith, that in the presence of vegetation the amount of carbonic acid gas present in the air varied greatly from hour to hour, and also by day and night. It was known that gases distributed themselves independently under the influence of gravity, and therefore there ought to be a less amount of carbonic acid on mountains than on plains. He did not think the difference in elevation between Geneva and the Dole was sufficient to determine this question. It was desirable to have a series of continuous observations made at places varying greatly in elevation above sea level to arrive at any satisfactory and conclusive results. He had a great mistrust of averages deduced from a short series of observations.

Mr. Gaster thought that Dr. Marcet's and Dr. Russell's diagrams supported each other very strongly. It was evident from them that, notwithstanding its high specific gravity, carbonic acid tended to distribute itself freely from the earth's surface (where it is generated) into the higher regions of the atmosphere. This tendency to diffusion was stopped by fog; so that at low levels, as in London, the amount of carbonic acid increased enormously during the prevalence of thick fogs, while at higher levels the presence of cloud-fog around the observer prevented the carbonic acid from reaching him. The result was that fogs at the earth's surface gave an excess, while those at a considerable altitude gave a deficit of carbonic acid.

Dr. Marcet in reply said he did not consider the amount of carbonic acid in the air of the country near Geneva was large, as the average of his experiments gave only 3·82 parts in 10,000 of air in summer when vegetation was active. He certainly agreed that a longer series of observations was desirable and necessary, but stated that the labour involved in making the present series of experiments was by no means light. Regarding Dr. Angus Smith's results he said that no information was given concerning the weather, and the experiments near Geneva clearly showed that the conditions of weather did have an influence upon the amount of carbonic acid in the air. In fact, the point which he had sought to bring out by his Paper was the relation which the weather had to the amount of carbonic acid found in the air.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

January 19th, 1887.

Ordinary Meeting.

William Ellis, F.R.A.S., President, in the Chair.

J. Willis Bund, 3 Stone Buildings, Lincoln's Inn, W.C., was balloted for and duly elected a Fellow of the Society.

The following Papers were read :—

"On the Identity of Cloud Forms all over the World; and on the general principles by which their Indications must be read." By the Hon. Ralph Abercromby, F.R.Met.Soc. (p. 140.)

"On the Cloud to which the name 'Roll Cumulus' has been applied." By the Hon. Ralph Abercromby, F.R.Met.Soc. (p. 147.)

The Meeting was closed at 8 p.m., in order that the Annual General Meeting might be held.

JANUARY 19TH, 1887.

Annual General Meeting.

WILLIAM ELLIS, F.R.A.S., President, in the Chair.

Mr. J. S. DYASON and Mr. R. STRACHAN were appointed Scrutineers of the Ballot for Officers and Council.

Dr. TRIPE read the Report of the Council and the Balance Sheet for the past year. (p. 114.)

It was proposed by the PRESIDENT, seconded by Dr. TRIPE, and resolved:—"That the Report of the Council be received and adopted, and printed in the *Quarterly Journal* of the Society."

It was proposed by Dr. WILLIAMS, seconded by Mr. BREWIN, and resolved:—"That the best thanks of the Royal Meteorological Society be communicated to the Council of the Institution of Civil Engineers for having granted the Society free permission to hold its Meetings in the rooms of the Institution."

It was proposed by Mr. W. H. ELLIS, seconded by Col. BROOKE, and resolved:—"That the thanks of the Society be given to the Officers and other Members of the Council for their services during the past year."

It was proposed by Mr. LECKY, seconded by Mr. CORY, and resolved:—"That the thanks of the Society be given to the Standing Committees, to the Auditors, and to the Referees of Papers; and that the Committees be requested to continue their duties till the next Council Meeting."

The PRESIDENT (Mr. Ellis) then delivered his Address. (p. 101.)

It was proposed by Mr. SCOTT, seconded by Mr. LAUGHTON, and resolved:—"That the thanks of the Society be given to the President for the ability and courtesy displayed by him in the Chair during the past year, and for his Address, and that he be requested to allow it to be printed in the *Quarterly Journal* of the Society."

The Scrutineers declared the following gentlemen to be Officers and Council for the ensuing year, viz.:—

President.

WILLIAM ELLIS, F.R.A.S.

Vice-Presidents.

GEORGE CHATTERTON, M.A., M.Inst.C.E.
CHARLES HARDING.
CUTHBERT EDGAR PEEK, M.A., F.R.A.S., F.R.G.S.
GEORGE MATHEWS WHIPPLE, B.Sc., F.R.A.S.

Treasurer.

HENRY PERIGAL, F.R.A.S., F.R.M.S.

Trustees.

HON. FRANCIS ALBERT ROLLO RUSSELL, M.A.
STEPHEN WILLIAM SILVER, F.R.G.S.

Secretaries.

GEORGE JAMES SYMONS, F.R.S.
JOHN WILLIAM TRIPE, M.D., M.R.C.P.ED.

Foreign Secretary.

ROBERT HENRY SCOTT, M.A., F.R.S., F.G.S.

Council.

HON. RALPH ABERCROMBY.
EDMUND DOUGLAS ARCHIBALD, M.A.
FRANCIS CAMPBELL BAYARD, LL.M.
WILLIAM MORRIS BEAUFORT, F.R.A.S., F.R.G.S.
ARTHUR BREWIN.
FREDERICK WILLIAM CORY, M.R.C.S.
HENRY STORKS EATON, M.A.
RICHARD INWARDS, F.R.A.S.
BALDWIN LATHAM, M.Inst.C.E., F.G.S.
WILLIAM MARCET, M.D., F.R.S., F.C.S.
EDWARD MAWLEY, F.R.H.S.
CHARLES THEODORE WILLIAMS, M.A., M.D., F.R.C.P.

FEBRUARY 16TH, 1887.

Ordinary Meeting.

WILLIAM ELLIS, F.R.A.S., President, in the Chair.

EDWARD TICKNER EDWARDS, Camp Field, Overhill Road, Dulwich;
DESMOND FITZGERALD, Brookline, Mass., U.S.A.;
THOMAS BENNETT GROVES, F.C.S., Weymouth; and
WILLIAM WALLER MIDGLEY, Chadwick Museum, Bolton,
were balloted for and duly elected Fellows of the Society.

The Council Secretary, Dr. TRIPE, read a letter received from Sir F. Abel, F.R.S., Organising Secretary to the proposed Imperial Institute, inviting the Society to draw the attention of the Fellows to the undertaking, with the view of their contributing towards it.

The PRESIDENT stated that a copy of the letter and of the accompanying paper, explanatory of the scheme, would be forwarded to the Fellows.

The adjourned Discussion on the HON. R. ABERCROMBY'S Paper "On the Identity of Cloud Forms all over the World, and on the General Principles by which their Indications must be read," was resumed; after which the following Papers were read:—

"REMARKS CONCERNING THE NOMENCLATURE OF CLOUDS FOR ORDINARY USE." By Dr. H. H. HILDEBRANDSSON, Hon.Mem.R.Met.Soc. (p. 148.).

"SUGGESTIONS FOR AN INTERNATIONAL NOMENCLATURE OF CLOUDS." By the HON. RALPH ABERCROMBY, F.R.Met.Soc. (p. 154.)

"THE INFLUENCE OF WEATHER ON THE PROPORTION OF CARBONIC ACID IN THE AIR OF PLAINS AND MOUNTAINS." By W. MARCET, M.D., F.R.S., F.R.Met.Soc., and A. LANDRISET. (p. 166).

CORRESPONDENCE AND NOTES.

"NOTES ON A VOYAGE ACROSS THE NORTH ATLANTIC, JANUARY 31ST TO FEBRUARY 10TH, 1887." BY RICHARD LADD, F.R.Met.Soc.,F.R.A.S.

I ARRIVED at Halifax, Nova Scotia, on February 10th, after a very rough passage, not a day without a gale of wind and tremendous seas. On February 1st we experienced a whole gale from West with furious squalls to force 11, with hail and rain, which lasted till midnight of the 3rd, from lat. 48° 5′ N. long. 32° 11′ W. to lat. 47° N. long. 36° W. Three waterspouts were seen. On the 4th another gale sprang up in the evening from South-west; the wind afterwards backed to South, and increased to a whole gale with heavy rain; and at 5 a.m. on the 5th veered to West with terrific squalls to force 11, accompanied with snow and hail and tremendous confused sea, which lasted till midnight. Waterspouts were also seen during this gale. This storm lasted from lat. 46° 30′ N. long. 39° 15′ W. to lat. 45° N. and long. 42° W. On the 7th in the morning the wind sprang up from East in lat. 44° 30′ N. and long. 45° 30′ W., and veered about noon suddenly to South-south-west, thick with snow. The wind increased from 4 to 8, and at 1.30 p.m. suddenly veered to North-north-east, and blew a whole gale with drizzling rain, and then subsided about 10 p.m. in lat. 43° 20′ N. and long. 47° 40′ W. These were the three remarkable gales of the passage.

During the remainder of the passage the winds were strong from South-west, West, and North-west, and very cold, the thermometer falling as low as 24°, and the sea temperature off the tail of the Grand Bank to 29°. No ice was seen.

The following are our highest and lowest barometer readings :—

	Ins.		Ins.
Jan. 31st, 8 p.m.	30·117.	Feb. 7th, noon,	29·238.
Feb. 2nd, 8 a.m.	29·361.	„ 8th, midt.	30·489.
„ 4th, noon,	30·193.	„ 9th, 4 p.m.	29·383.
„ 5th, 4 a.m.	29·296.	„ 10th, „	30·126.
„ 6th, 8 p.m.	30·234.		

[While the above has been passing through the press, news has reached this country that Mr. Ladd died on May 3rd.—ED.]

SYNCHRONOUS WEATHER CHARTS OF THE NORTH ATLANTIC AND THE ADJACENT CONTINENTS FOR EVERY DAY FROM 1ST AUGUST, 1882, TO 31ST AUGUST, 1883.

PARTS 1 and 2 of the valuable set of Daily Synchronous Weather Charts of the North Atlantic, prepared by the Meteorological Council, have just been issued. The Charts are accompanied by a sheet of *Explanatory Notes*, which we give *in extenso* :—

"The study of the weather of Western Europe for many years has established in a manner that is beyond question, that the atmospheric disturbances, on which the changes of weather are in a great measure, if not mainly, dependent, reach our Western coasts after having passed for a longer or shorter distance over the Atlantic. With a view to ascertaining as far as possible the conditions under which such disturbances either originate in, or traverse the Atlantic, and the extent to which the direction of their course, their magnitude and persistence, may be influenced by the general meteorological conditions of the area within which they are generated, or of the regions which surround that area, the Meteorological Council have undertaken an investigation into the weather over the North Atlantic and the adjacent continents, the results of which are represented in these charts.

"The data have been obtained from observations extending over a period of thirteen months, from August 1st, 1882, to August 31st, 1883, collected from a very large number of ships, and they supply the means of exhibiting with very considerable precision the principal meteorological elements for every day during this period over the whole area dealt with.

"In all, 11,236 returns, each containing the records of many days, have been received from about 3,000 vessels. The number of returns for the several months are as follows:—

1882.		1883.			
August	826				
September	881	January	787	May	905
October	932	February	835	June	841
November	861	March	927	July	843
December	849	April	964	August	785

"These yield, on an average, observations from rather more than 400 ships for each day, in addition to which daily observations from about 300 land stations have been used.

"The period embraced having been that during which the International system of Circumpolar Observations was being carried out, data have been obtained from very high northern latitudes, which could not otherwise have been procurable, and hence the results embodied in the charts have not only been rendered far more complete, but are of an exceptional value, not likely to be soon equalled.

"The charts are on the conical projection. They were originally drawn on a much larger scale, 1 inch to 180 nautical miles, and on these the observations of barometer, wind, weather, and air and sea temperature from each ship were plotted in their proper positions. From these the charts in the present publication have been reduced. There are two for each day—one to show the barometric pressure, the wind, and the weather, and the other to show the temperature of the air and sea, and the weather.

"The question of time to be followed in recording the observations on the charts, whether it should be Greenwich noon or local noon, the former implying that the observations would be truly synchronous, and the latter that they would correspond to the time of the sun's coming to the local meridian, received careful consideration. The conclusion arrived at after examining the methods employed by other authorities in dealing with such investigations (including the charts recently prepared by the Deutsche Seewarte) was to enter on the chart the barometer reading and wind for Greenwich noon, thus making the values truly synchronous, but to enter the thermometer reading for local noon.

"As the ordinary diurnal variations of pressure over the area dealt with are comparatively small, they will probably have but little influence in determining the directions of the wind, or the movements of aerial disturbances across the Atlantic, which are mainly determined by barometric changes due to other causes. Moreover, local noon on the western side of the charts in long. 75° W. is about six hours later (absolutely) than local noon on the extreme east of the charts in long. 20° E., so that had the observations at local noon been made use of, apparent changes of pressure on the west as compared to the east would have been indicated on the charts which had not really occurred, and could not have been influential in determining the atmospheric disturbances and wind systems, which usually move from west to east, and often with considerable rapidity. The conclusion was therefore come to that the observations of pressure to be represented should be truly synchronous.

"In the case of temperature the conditions differ materially from those affecting pressure. The diurnal changes of temperature, though not great, would, if synchronous observations at Greenwich noon were used, introduce an appearance of permanent higher temperature to the east as compared with the west, as such observations in the extreme west would be made five or six hours before local noon, while those in the extreme east would be one or two hours after local noon; a difference of temperature which would not have any true physical significance so far as probable consequent changes of pressure or general weather were concerned. Consequently it was determined to adopt the temperature at noon, local time, for entry over the sea. The isotherms over the land are taken from various published weather charts, and the hours to which they refer are stated below.

"The following is an explanation of the manner in which the several elements have been dealt with on the charts:—

"BAROMETER.—From the observations as directly recorded, the pressure has been deduced by interpolation for Greenwich noon of each day, and is entered at the point corresponding to the ship's place at the time; so that the barometrical pressures shown on the charts are strictly synchronous.

"Isobars, or lines of equal barometric pressure, represented by black lines, are drawn for each tenth of an inch, an intermediate dotted line for the half-tenth being occasionally introduced. To facilitate comparison, the line corresponding to 29·9 ins. (nearly equivalent to 760 mm.), which is approximately the mean barometric pressure over the sea surface generally, is thicker than the rest. A broken line is used to indicate the probable position of the isobars where the observations are insufficient to establish a satisfactory degree of certainty. Figures in the central area of a depression show the lowest reading of the barometer recorded by the vessels which passed through it.

"WIND.—The arrows indicating the direction and force of the wind fly with the wind. The scale of the reduced charts is too small to admit of every observation being shown, and where necessary a generalisation has been made, in many cases an arrow representing as many as ten or more independent observations. It has been found that where vessels are numerous, even though they are chiefly steamers, there is, as a rule, a most satisfactory agreement in the recorded direction and force of the wind. At some land stations, however, in the neighbourhood of mountains, the recorded wind is often directly opposed to the prevailing current of air as shown by ships at sea. This is no doubt a result of eddies caused by high land lying to windward of the station. The wind at Funchal, Madeira, is often so influenced.

"The winds at high level stations, indicated by red arrows, are all at elevations of 4,000 feet or upwards. The heights of these stations are shown on the key chart.

"WEATHER.—The weather is shown by appropriate shading on both the pressure and temperature charts, to facilitate comparison with the different elements. The shaded areas show the position of rain, fog, or mist. Snow is classed with rain, whilst hail and drizzle are grouped with passing showers. Broadly speaking, those parts of the ocean which the records of observations show to have been traversed by ships, and which are free from shading, may be considered as experiencing fine weather,

"AIR TEMPERATURE.—The air temperatures over the Atlantic are those recorded at noon, local time. Air isotherms, or lines of equal air temperature, are shown by red lines over the sea for each 5° Fahrenheit: the thick red lines are isotherms, at 10° apart, over the land; those over America being for Greenwich noon, and over Europe for about 8 a.m. local time; a broken line indicates doubt.

"At a few land stations the air temperature has not been available at the hours above mentioned. These stations are distinguished by a note on the key-chart.

"SEA TEMPERATURE.—Sea isotherms, or lines of equal sea temperature, also for local noon, are shown by black lines for each 5° Fahrenheit.

"In some cases, where the data were not sufficient to admit of isobars or isotherms being drawn, isolated observations are entered in figures.

"A key chart shows the positions and names of the various circumpolar stations and of mountain stations with their heights in feet, also the names of islands or coast stations other than those which have been employed in the drawing of isobars and isotherms by the North American or European meteorological authorities in preparing their daily charts, from which charts the land data made use of have for the most part been obtained. On this chart the North-east coast of South America is shown, as it most probably affects the winds and weather in the neighbouring part of the North Atlantic."

RECENT PUBLICATIONS.

American Meteorological Journal. A Monthly Review of Meteorology, Medical Climatology, and Geography. December 1886—February 1887. Vol. III. Nos. 8-10. 8vo.

The principal papers are: Connection between Meteorology and Terrestrial Magnetism, by R. Owen, Parts II. and III. (9 pp.).—Loomis' "Contribution to Meteorology," by H. H. Clayton (29 pp.).—An Investigation of Cyclonic Phenomena in New England, by W. Upton (26 pp.). The author in this paper investigates the storm of January 9th, 1886, which traversed New England, and was a remarkably complete example of those cyclones which move along the Eastern States from the Gulf of Mexico: in the concluding Part the author treats of cyclones with a secondary development, or instances in which two cyclones unite near New England.—Ball or Globe Lightning, by R. Owen (2 pp.).—The Sonnblick Observatory, the highest meteorological station in Europe, by A. L. Rotch (2 pp.).—Sensitiveness of the Wind Vane, by W. Ferrell (2 pp.).—An Experiment in Local Weather Prediction, by A. L. Rotch (4 pp.).—The Chinook Winds, by M. W. Harrington (8 pp.).

Annales du Bureau Central Météorologique de France.—Publiées par E. Mascart, Directeur. Année 1884. 4to. 1886. Part I.

This volume is devoted to papers on Storms in France, and various memoirs. In addition to reports on Storms by MM. Fron and Lespiault, it contains the following papers:—Observations magnétiques faites à l'observatoire du Parc Saint Maur pendant les années 1883 et 1884, par M. Moureaux (52 pp. and 16 plates).—Détermination des éléments magnétiques en France; nouvelles cartes magnétiques, par M. Moureaux (171 pp. and 4 plates).—Etude sur la marche des phénomènes de la végétation et la migration des oiseaux en France, pendant les années 1882 et 1883, par A. Angot (61 pp. and 16 plates).

Annuaire de l'Observatoire Royal de Bruxelles, par F. Folie, Directeur. 1887. 54 me Année. 8vo. 577 pp. 1886.

Among much other valuable information this contains articles on the following subjects:—Sur les marées atmosphériques (2 pp.).—Le climat de la Belgique en 1886, par A. Lancaster (71 pp. and 2 plates).—Sur la réduction des indications barographiques, par L. D. Moreau (11 pp.).—Liste générale des Observatoires et des Astronomes, des Sociétés et des Revues Astronomiques, preparée par A. Lancaster (114 pp.).

Annuario Meteorologico Italiano. Pubblicato per cura del comitato Direttivo della Società Meteorologica Italiana. Anno II. 1887. 8vo. 264 pp.

In addition to the usual information, this contains in Part 4 the following papers: Macchie solari e magnetismo terrestre, del Padre S. Ferrari (8 pp. and plate).—Le stelle cadenti del 27 Novembre, 1885, di G. Celoria (7 pp.).—La polvere dell' atmosfera, di G. Celoria (13 pp.).—Lo studio dell' aria applicato alla Igiene, di G. Roster (16 pp.).—Il cholera in rapporto coi fenomeni meteorologici, di L. Pagliani (12 pp.).—Il vulcanismo e le acque, di A. da Schio (22 pp.).—Notizie di Meteorologia e Fisica Terrestre, del Padre F. Denza (19 pp.).—Bibligrafia meteorologica italiana del 1886 (4 pp.).

Ciel et Terre. Revue populaire d'Astronomie, de Météorologie, et de Physique du Globe. January-March 1887. 8vo.

The principal meteorological articles are:—Les Méthodes d'investigation scientifique et leur application à la science des climats, par A. Piche (11 pp.).—Stations météorologiques forestières (7 pp.).—La température des mers et le refroidissement du globe (8 pp.).

Das Wetter. Meteorologische Monatsschrift für Gebildete aller Stände. Herausgegeben von Dr. R. **Assmann**. November-December 1886. 8vo.

In addition to the usual monthly reports on the weather in Central Europe, the Nos. contain the following articles: Richtung und Geschwindigkeit der Gewitter in Frankreich und Italien, von Dr. C. Ferrari (3 pp.).—Die Meteorologie der Sonne und ihrer Systeme, von Prof. Zenger, Besprochen von Dr. J. M. Pernter (6 pp.).—Ueber Wärme-Gewitter, von F. Melling (7 pp.).—Der Alpenföhn (9 pp.).

Journal of the Scottish Meteorological Society. Third Series, No. III. 8vo. 1886.

The principal articles are: The Wet-Bulb Hygrometer, its use and efficiency, by Prof. Piazzi Smith (9 pp.).—The Winds and Rainfall of Ben Nevis in 1885, by R. T. Omond (4 pp.). There were forty-seven days during the year on which over 1 inch of rain was recorded, and on ten of these days more than 2 inches fell. The heaviest fall was 5·340 ins. on Dec. 12th, of which 4·313 ins. fell between 10 a.m. and midnight. Most of the days with over an inch of rainfall were marked by a minimum reading of the barometer.—Rainband Observations on Ben Nevis, by A. Rankin (6 pp.).—Recent Literature of the Rainband, by H. R. Mill, D.Sc. (4 pp.).—On the Temperature of the Water in the Firth of Clyde, by H. R. Mill, D.Sc. (7 pp.).—Meteorology of Ben Nevis for the year ending 31st May 1886, by A. Buchan (8 pp.).

Les Perturbations Atmosphériques etudiées au moyen d'Observations Horaires, par A. E. Arkenbout Schokker, ex-officier de Marine. Publié par l'Institut Météorologique, Utrecht. 16 pp. and 24 charts. Foolscap folio. 1886.

This has been an investigation undertaken at the suggestion of Prof Buys-Ballot to carry out further the plan of Mr. Marriott's Papers on the Storms of January 24th, 1872, and January 26th, 1884,[1] in which isobaric charts at frequent intervals are given. M. Schokker has taken the period November 16th-18th, 1880, and has drawn isobaric charts for Europe for every hour during that interval by the aid of the various observatories which yield continuous records. The charts exhibit very different degrees of completeness, those which correspond to the ordinary observation hours of the various systems being by far the most complete. The outcome of the inquiry, which is very instructive, is that the changes of the situation were much more complicated than the ordinary telegraphic reports would show, and the author concludes with an earnest appeal for the general introduction of telemeteorography.

Meteorologische Zeitschrift. Herausgegeben von der oesterreichischen Gesellschaft für Meteorologie und der deutschen meteorologischen Gesellschaft. Redigirt von Dr. J. **Hann** und Dr. W. **Köppen**. January-March 1887. 4to.

Contains: Beiträge zur Kenntniss des Klimas der Kanarischen Inseln, von Dr. Biermann (11 pp.). This is an account of all the available information for the climate of the Canary Islands, which is unfortunately not very copious. It is prefaced by some interesting notes on the action of the North-east Trade (called locally *brisa*) as regards the formation of clouds, and their disappearance when they come into the lee of the mountains, the region called *banda*.—Periodische Schwankungen der Atmosphäre zwischen beiden Halbkugeln der Erde, von Magister J. Kleiber (3 pp.). The author shows how the areas of high and low pressure change hemispheres with the season; and he advocates the adoption of Lambert's Isocylindrical projection as giving less distortion than Mercator's. In it the meridians and parallels are straight lines and at right angles to each other, and the distance of the latter from the equator varies with the sine of the latitude.—Beobachtung der Schneebedeckung, von C. Lang (5 pp.). This is an account of the instructions issued for the regular observations of snow—fall, depth, and condition—in Bavaria.—Begleitworte zur synoptischen Karte des nordatlantischen Oceans und der angrenzenden Gebiete für den 1. September 1883, von Dr. Grossmann (5 pp. and plate).—Die meteorologische Beobachtungsstation auf dem Gipfel des Sonnblick, von Prof. A. von Obermayer (9 pp.).—Zur Geschichte der meteorologischen Station auf dem Hohen Sonnblick, von Dr. J. Hann (4 pp.).—Die ersten Resultate der meteorologischen Beobachtungen auf dem Hohen Sonnblick (3100 m.) October-December 1886, von Dr. J. Hann (10 pp.). These three papers refer to the Sonnblick Observatory, which has an elevation of over 10,000 feet, and lies in the latitude of Bad Gastein, and near the Gross Glockner. Prof. v. Obermayer's paper gives a popular account of a visit to the station. Dr. Hann's first paper gives the history of the undertaking, and his second, the results of the first two months' work.—Die vertikale Vertheilung und die Maximalzone des Niederschlags am Nordabhange der bayerischen Alpen im Zeitraum November 1883 bis November 1885, von Dr. F. Erk (14 pp.). This is a paper to show that in the Bavarian Alps there exists a level of maximum precipitation like that shown by Mr. S. A. Hill to exist in the Himalayas. Dr. Erk points out that as the Bavarian Alps rise nearly sheer from the tableland they yield far better results than the other parts of the Alpine chain. The final result of the paper is thus stated: "There exists a seasonal vertical displacement of the zone of maximum rainfall on the northern slopes of the Alps of Bavaria, and this as far as the available evidence goes to prove, depends in the first instance on the annual march of temperature. In winter we frequently find a definite single maximum zone at the level of from 1,800 to 3,000 feet, but it must be admitted that this does not appear regularly, nor does it last through the whole winter, but it may be contrasted with the inversion of temperature which appears nearly every winter, and is also subject to occasional interruption."—Die Höhe der Wolken im Sommer zu Upsala, von N. Ekholm und K. L. Hagström (6 pp.). The authors find that all the forms of cloud may appear at almost any level, but they exhibit a tendency to development at definite levels. The chief results arrived at are the following: 1. The level of the base of cumulus clouds rises from morning till evening; 2. The height of the summit and the thickness has a maximum at about 1.30 p.m.; 3. The increase in the forenoon is more rapid than the decrease in the afternoon. In the morning, when the cirrus clouds are lowest, the frequency of their lowest forms (cirro-cumulus) is greatest; in the evening, when the cirrus are highest, the frequency of their highest forms (cirro-stratus) is greatest.—Das Küstenklima der Provinz Pernambuco, von Prof. F. M. Draenert (5 pp.).—Beiträge zur Kenntniss der Niederschlagsverhältnisse von Deutschland, von Dr. G. Hellmann (12 pp.). This is an examination into the variation with elevation above sea-level in the seasonal distribution of rainfall.—Die Gewitter in Prag von 1840-1885, von W. Láska (3 pp.).

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[1] *Quarterly Journal of the Royal Meteorological Society*, Vol. I. p. 188, and Vol. X. p. 114.

NEGRETTI AND ZAMBRA'S ENCYCLOPÆDIC ILLUSTRATED AND DESCRIPTIVE REFERENCE CATALOGUE of Optical, Mathematical, Physical, Photographic, and Standard Meteorological Instruments. Revised and corrected edition, 602 pp. 8vo. 1887.

This work is not merely a list of prices, but is in reality a treatise on scientific instruments and apparatus, and is illustrated by upwards of thirteen hundred wood engravings. The description of meteorological instruments occupies a large portion of the book, and is of a very interesting and useful nature.

PROCEEDINGS OF THE ROYAL SOCIETY. Vol. XLII. Nos. 251-252. 1887. 8vo.

Contains: Some Anomalies in the Winds of Northern India, and their relation to the distribution of Barometric Pressure, by S. A. Hill (2 pp.). The author points out that notwithstanding the great amount of light thrown upon the circulation of the atmosphere over Northern India by the accurate and intercomparable barometric and other observations made at numerous meteorological stations during the last thirteen years, there are still some unexplained anomalies connected with the wind system of that part of the world. The most important of these anomalies are the following:—1. The winds of the hot season not infrequently blow against a rising barometric gradient, *i.e.* from places where the pressure is low to others where it is higher; (2) The velocity of the wind has little or no relation to the distribution of pressure, but increases and diminishes with the temperature; (3) An unusual accumulation of snow on the North-west Himalaya during the winter and spring months causes, as Mr. H. F. Blanford has shown, unusually strong dry Westerly winds over the plains during the succeeding summer; whereas the high pressure at sea-level accompanying cold over the regions to the north of India should give rise to Easterly winds.—On the Relation between tropical and extra-tropical Cyclones, by the Hon. R. Abercromby (3 pp. Abstract). The author finds that tropical and extra-tropical cyclones are identical in general character, but differ in certain details, due to latitude, surrounding pressure, and to the relative intensity of rotation or translation.

SUPPLEMENTBANDE ZUM REPERTORIUM FÜR METEOROLOGIE. Herausgegeben von der Kaiserlichen Academie der Wissenschaften. 4to. 1887.

Supplementband II. is entitled "Ueber den Auf-und Zugang der Gewässer des Russischen Reiches," bearbeitet von M. Rykatschew (415 pp. and 3 plates). This is an elaborate discussion of all the records of the dates on which the rivers in the Russian Empire were frozen in the autumn, and open for navigation in the spring.

Supplementband III. is entitled "Wahre Tagesmittel und tägliche Variation der Temperatur an 18 Stationen des Russischen Reiches," von E. Wahlén (xxi. + 535 pp.).

The author gives the mean temperature for each day at the following 18 stations in Russia, viz.:—

Station.	Lat. N.		Long. E.		Height above sea. ft.	Period.
	°	′	°	′		
Archangel	64	33	40	32	33	1813-1882
Port Baltic	59	21	24	3	33	1839-1882
Vilna	54	41	25	18	394	1777-1882
Warsaw	52	13	21	2	394	1779-1882
Lugan	48	35	39	20	197	1837-1882
Astrakhan	46	21	48	2	66	1837-1882
Ekaterinburg	56	49	60	35	886	1831-1882
Bogoslovsk	59	45	60	1	623	1838-1882
Barnaul	53	20	82	47	459	1838-1882
Yakutsk	62	1	129	42	525	1829-1873
Nertchinsk	51	19	119	37	2165	1839-1881
Kem	64	57	34	39	33	1862-1882
Viatka	58	36	49	41	591	1845-1882
Kiev	50	27	30	30	591	1856-1882
Irgis (Fort Uralsk) ...	48	37	61	16	361	1862-1882
Alexandrovsk	44	31	50	16	82	1849-1882
Yeniseisk	58	27	92	6	262	1871-1882
Nikolaievsk-on-Amoor	53	8	140	43	66	1854-1882

Supplementband IV. is entitled "Katalog der meteorologischen Beobachtungen in Russland und Finland," von E. Leyst (xxii. + 425 pp.), and gives a list of all the stations in Russia and Finland at which meteorological observations have been made down to the year 1885. The number of stations mentioned is for European Russia, 846; for the Caucasus, 106; for Asiatic Russia, 214; and for Russian America, 9; total 1,175.

SYMONS'S MONTHLY METEOROLOGICAL MAGAZINE, Nos. 252-254, January-March, 1887. 8vo.

The principal articles are:—The Snowstorm of December 26th, 1886 (3 pp.).—Enormous Snow-flakes, January 7th, 1887, by E. J. Lowe (1 p.).—The recent Summer and the Weather Cyclists (3 pp.).—Evaporation (2 pp.).—Day and Night Breezes, by T. W. Backhouse (2 pp.).—The Earthquake in the Riviera (5 pp.).

The Journal of the National Fish Culture Association, including a Summary of current information on Fish, Fish Culture, and Fisheries. Edited by J. W. Willis Bund, M.A., F.L.S. Vol. I. No. 1. January 1887. 8vo.

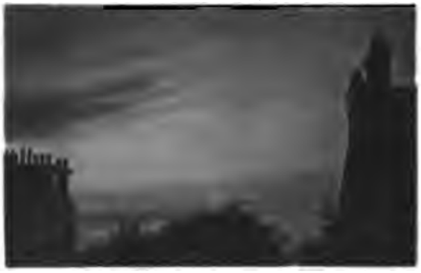
The object of this work is to become a periodical record of information on Fish and Fisheries. It is intended to contain original articles, notes of the proceedings of the Fishery Department and Fishery Boards, information as to Inland and Sea Fisheries, and such information as can be obtained of Fish Culture and Fisheries in the Colonies and abroad. The present No. contains a Paper by Mr. Bund on "The influence of Weather on the migration of Fish" (9 pp.). The author finds that on the Severn the different elements which are required to bring about a good run of fish appear to be: 1. a spring tide; 2. a South-west wind; 3. a higher temperature of the water in the estuary than the land water in the river; 4. a low but steadily rising barometer to a height of 29·5 ins.; and 5. a moderate rise of land water.

The Scottish Geographical Magazine, Vol. III. Nos. 1-3. January-March 1887. 8vo.

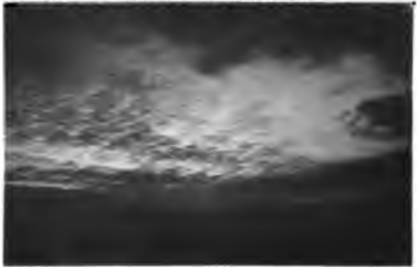
This contains, among other interesting articles, the following papers:—Configuration of the Clyde Sea-area, by H. R. Mill, D.Sc. (6 pp. and plate).—On the Total Annual Rainfall on the Land of the Globe, and the Relation of Rainfall to the Annual Discharge of Rivers, by John Murray (12 pp. and plate).

Quart. Journ. Roy. Met. Soc. Vol. XIII. Pl. III.

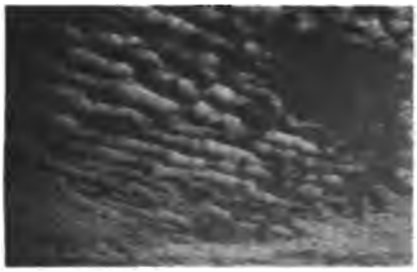
ABERCROMBY TYPICAL CLOUD FORMS.



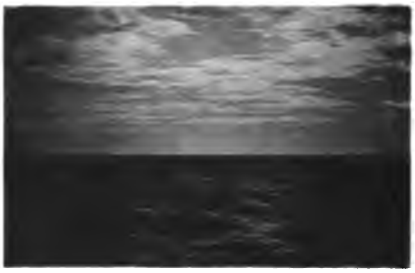
1. *Cirrus.*



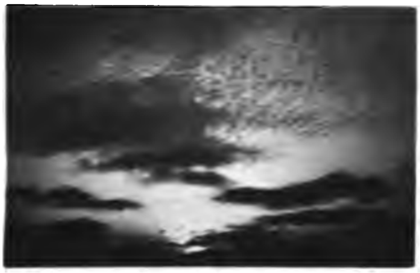
2. *Cirro-Stratus.*



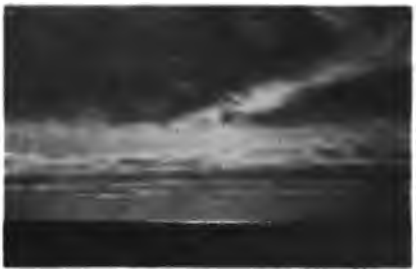
3. *Cirro-cumulus.*



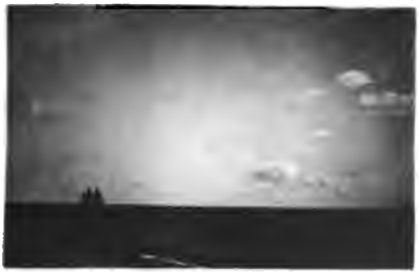
4. *Strato-cirrus.*



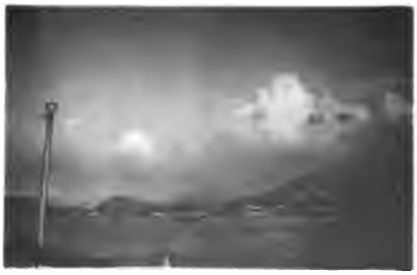
5. *Cumulo-cirrus*



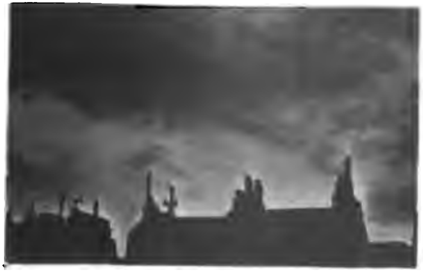
6. *Strato-cumulus.*



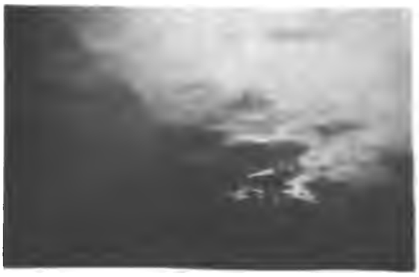
7. *Cumulus.*



8. *Cumulo-nimbus.*



9. *Nimbus.*



10 *Stratus.*

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Quarterly Journal

OF THE

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EDITED BY A

COMMITTEE OF THE COUNCIL.

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Royal Meteorological Society.

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SESSION 1887-8.

ORDINARY MEETINGS AT 7 p.m.

Wednesday,	November	16, 1887
,,	December	21, ,,
,,	January*	18, 1888
,,	February	15, ,,
,,	March	21, ,,
,,	April	18, ,,
,,	May	16, ,,
,,	June	20, ,,

* Annual General Meeting.

By permission of the Council of the Institution of Civil Engineers, the above Meetings will be held at 25 Great George Street, Westminster, S.W.

QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY.

VOL. XIII. JULY 1887. No. 68.

NOTES ON TAKING OBSERVATIONS, &c., ON BOARD SHIP.

By D. WILSON-BARKER, R.N.R., F.R.MET.SOC., F.R.G.S., &c.

[Read March 16th, 1887.]

THE value of observations taken on board ship is very often much diminished owing to the instruments being placed in bad positions. Great care is taken in the placing of instruments on land, why should not the same care be taken on board ship? especially as observations taken at sea will eventually be very valuable. I have once seen on one of H.M. ships the dry and wet bulb thermometers placed in a short passage joining two side alley ways under the poop; and also once on board a large merchant vessel in a passage leading from the main deck to the saloon, the outer door of which, in bad weather, was closed, thus entirely excluding the outer air. In these cases it is needless to say the observations were valueless, yet they were continually registered. A few suggestions as to the placing of instruments and taking of observations are much needed. At present there are no rules as to these matters, and rules would tend to make the observations more reliable.

1. *Barometer.*—This most important instrument should be easy of access, and yet not likely to be knocked against, or to knock its cistern against anything during the violent motion of the ship, or experience sudden changes

of temperature. The chart room in most steamers is a good place, it is generally near the centre of the vessel and easy of access for the officers. In sailing ships the barometer should be placed in the fore part of the saloon, and as near as can be on the fore and aft line. In such places, the chart room or saloon, it is convenient for reading off by day or night.

2. *Thermometers.*—In the *Instructions* issued with the instruments, it is advised to have them well screened from spray and sun. Why? Are they so on land? If they are screened from spray and sun the air is kept away. One case I shall mention: the thermometers were under a bridge-deck screened all round except in front by a wood casing. Did this show the true temperature of the air? The best place is on the bridge, as it is only in very bad weather that spray is thrown up there; it is well exposed, and in a good position for taking the observations. It will be noticed, if the screen be left open for some minutes after reading, that the thermometers will register a different temperature by some tenths; it should be made a rule that the thermometers should be read, either directly the screen is opened, or at a certain interval afterwards. I prefer reading directly the screen is opened. At times moisture condenses on the dry bulb; when the observer thinks this is likely, he should wipe the bulb with a dry cloth some little time before taking the observations. In sailing ships, the pole supporting the standard compass or one of the masts offers a good place for the screen, if it can be kept clear of the ropes. It may be as well to remark that in the case of some steamers the funnel may be quite close to the bridge, and in that case it may be necessary to find some other place for the screen, but I strongly recommend that wherever it is suspended it should be as clear of surroundings as possible. The bulbs, muslin, cotton, and water should be kept scrupulously clean, and when sprays come over, the muslin on the wet bulb should be washed frequently to free it from salt, and the water in the glass changed. It has been recommended that the screen should be moved about the vessel, so that when the wind comes from the direction of the funnel it should not convey heat to it; I am afraid with a few exceptions this would not be carried out. The great thing in all these operations is to simplify them. I think a box with double louvres all round it, fitted with iron arms, top and bottom, to clamp on any stanchion, would be a good form of screen for use on board ship.

3. *Sea Surface Temperature and its Density.*—A small canvas bucket should be made, with a lanyard attached and kept handy to the bridge. The water should be drawn from the sea before the engine room, and the thermometer plunged in at once. It will be found that an immersion of from a half to one minute will give a fairly accurate temperature, and the same period of immersion should be allowed at all times. The observation for density can be taken at the same time, but this can only be considered as approximate. If accurate densities are required, one of Nicholson's hydrometers should be used; the glass in which it is immersed should rest on a swing tray, and the temperature be noted carefully.

4. *Wind Observations.*—In sailing ships it is comparatively easy to take good observations of the wind, but in steamers it is much more difficult, on

account of the rapid motion of the vessel. The direction of the wind should be judged from the ripples on the water; this is the best way. The force of wind is more difficult to deal with. I have already submitted to the Society[1] some experiments which I had made with two forms of anemometers at sea, and then showed that observations could be taken very well on board ship by either instrument. The agreement of these two perfectly dissimilar instruments was remarkable, and they have answered as well on subsequent observation. I don't say they measure the wind force accurately, but they register it correctly comparatively, and they do away with the uncertainty which always attends estimations of wind's velocity. Table I. (p. 188) shows approximate corrections for ship's speed, and angle of her course with the wind's direction. The time of wind shifting, varying in force, &c., should be carefully noted, and the barometer and thermometers read if thought necessary.

5. *Observations of the Sea Surface.*—Few directions are necessary for noting the motion of the waves, as this is generally an easy observation. At present the method for estimating the height of the waves seems somewhat vague. Table II. (p. 190) illustrates definitely the height of the waves with the corresponding figures now used. Frequently a heavy swell might give a wave height of 5, although the surface of the sea was without a ripple. A note in the remark column would at once settle this.

6. *Clouds.*—The most difficult subject for observers, and that attended by most mistakes. The misnaming of certain clouds is the cause of most error; *cirro-cumulus* and *cirro-stratus* for example; *nimbus* too—no matter from what form of cloud rain falls it is called *nimbus.* It should be noted (by beginners) that clouds of slight vertical depth, compared with their area, belong to the *stratus* types, while those that assume solid and rounded masses are *cumulus* forms. The movement of clouds is very difficult to determine at sea, but as they are very important, every attention should be paid to this. I give a Table III. (p. 190) for tabulating their velocities. A set of coloured glasses will be found very useful for determining the motions of the clouds over the sun. At night time advantage should be taken of the moon and stars, due attention being paid to the position of these bodies when taking the observation. It is comparatively easy at times to tell the movement of the cirriform clouds, as they nearly always move along the lines of filature. The points where the lines of filature appear to meet (called the V or radiant point) should be carefully noted in the remark column, or if the filature lines do not make a V point, the part of the horizon to which they are parallel. I give the following abbreviations (from the *Admiralty Manual of Scientific Enquiry*, 3rd Edition,) which are useful:—S for *stratus*, K for *cumulus*, N for *nimbus*, C for *cirrus*, CS for *cirro-stratus*, CK for *cirro-cumulus*, KS for *cumulo-stratus.* The following will serve as an example of noting down the clouds. Suppose the sky covered $\frac{4}{10}$ with *cirrus* moving from South-west fast, while below was *cumulus* covering $\frac{3}{10}$ of sky and moving from West at moderate speed, it should be noted thus, $\frac{C^4}{SW_4}\ \frac{K^3}{W}$, and should the *cirrus* be in lines showing a V point

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[1] *Quarterly Journal*, Vol. IX. page 241.

TABLE I.—For correcting Anemometer Readings.

2 Points.				
Speed of the Vessel in knots.	6	8	10	12
Velocity of Wind registered by Gauge.	Correction in Miles.			
Miles per hour.				
16	−5½	−7	−9	−11
24	−5	−7	−9	−11
32	−5	−7	−9	−11
40	−5	−7	−9	−11
48	−5	−7	−9	−11
56	−5	−7	−9	−11

4 Points.				
Speed of the Vessel in knots.	6	8	10	12
Velocity of Wind registered by Gauge.	Correction in Miles.			
Miles per hour.				
16	−5	−6	−8	−10
24	−5	−6	−8	−10
32	−5	−6	−8	−10
40	−5	−6	−8	− 9
48	−4	−6	−8	− 9
56	−4	−6	−7	− 9

6 Points.				
Speed of the Vessel in knots.	6	8	10	12
Velocity of Wind registered by Gauge.	Correction in Miles.			
Miles per hour.				
16	−3	−5	−6	−7
24	−3	−4	−5½	−6½
32	−3	−3½	−5	−6½
40	−3	−3	−5	−6
48	−3	−3	−5	−5½
56	−2½	−3	−5	−5½

8 Points.				
Speed of the Vessel in knots.	6	8	10	12
Velocity of Wind registered by Gauge.	Correction in Miles.			
Miles per hour.				
16	−1	−1¾	−3	−4
24	− ¾	−1	−2	−2¾
32	− ½	−1	−1½	−2¼
40	0	− ½	−1	−1½
48	0	− ½	−1	−0¼
56	0	− ¼	− ¾	−0¼

10 Points.				
Speed of the Vessel in knots.	6	8	10	12
Velocity of Wind registered by Gauge.	Correction in Miles.			
Miles per hour.				
16	+1	+1	+ ½	0
24	+1¾	+1¾	+1½	+1½
32	+1¾	+2	+2	+2
40	+2	+2½	+3	+3
48	+2	+2½	+3	+3
56	+2	+2½	+3	+3

12 Points.				
Speed of the Vessel in knots.	6	8	10	12
Velocity of Wind registered by Gauge.	Correction in Miles.			
Miles per hour.				
16	+3½	+4½	+4½	+4¼
24	+4	+5	+6	+6¾
32	+4¼	+5½	+6½	+7½
40	+4¼	+5¾	+7	+8
48	+4¼	+5¾	+7	+8
56	+4¼	+5¾	+7	+8

14 Points.				
Speed of the Vessel in knots.	6	8	10	12
Velocity of Wind registered by Gauge.	Correction in Miles.			
Miles per hour.				
16	+5½	+6¾	+8	+ 9
24	+6	+7½	+9	+10¼
32	+6	+7½	+9	+10½
40	+6	+7½	+9	+11¼
48	+6	+7½	+9	+11¼
56	+6	+7½	+9¼	+11½

Note.—Look in the Table, under angle in points between wind's true direction and ship's head, then under rate of vessel at time in knots per hour, with the Velocity of Wind per hour as shown by gauge, take out correction to be applied as sign directs. The result is the Wind's true Velocity.

Example.—Ship steering East, Wind's true direction South, gives angle 8 points; Velocity of Wind registered by Anemometer 24, and speed of Ship 10 knots, gives correction −2 to be applied to the 24, so that the wind's true velocity equals 22.

to South-west, it should be noted in the remark column thus, CV SW. Attention also should be paid to the height of the clouds, and notes made in the remark column. *Cirrus* frequently changes its level very rapidly, condensing from great heights to lower levels and changing into *cirro-cumulus*, then evaporating and appearing at the greatest heights again. Officers when on watch can easily note these changes.]

7. *Rain.*—This has received very little attention at sea, though I think a rain-gauge, fitted in gimbals[1] and placed in an open space, would give valuable information. It is to be desired that observations of the amount of rain that falls at sea should be obtained. There are six conditions under which rain falls: first, from the true *nimbus*, which is a dense stratiform cloud completely covering the sea or land over a large area; secondly, from *cumulus* clouds with clean bold outlines and cirriform tops; thirdly, from bold massive *cumulus* without any cirriform edges (only seen in the tropics); fourthly, from fleecy, ill-defined *cumulus*, as in drizzling showers; fifthly, very slight showers from the anticyclonic *stratus* at times; and sixthly, from a clear sky. This last condition is very rare.

8. *Currents.*—The estimation of the current experienced in a sailing ship depends on a correct register of the speed of the vessel and the leeway, and careful observations are extremely valuable; all care should be taken to obtain accurate results. In steamers it is more difficult to determine the currents, logs vary so much with different speeds. A good plan is to introduce the speed of the ship, determined from the screw revolutions, into that shown by the log or logs, and strike a mean. After a time this will be found to give fairly correct results.

9. *Weather* should be carefully noted, its actual state at the time of observation being registered, all past changes noted in the remark column. When squalls take place a small figure attached below will denote the force of wind, and a letter at the top will signify with what they were attended, whether it be rain, hail or snow; thus $q_6^{r\,t\,l\,f}$ denotes squalls with a wind force of 6, also accompanied by rain, thunder and fork lightning; their duration and frequency should be entered in the Remark column. I distinguish between squalls and showers by only calling them squalls when accompanied by an increase of wind force. Great attention should be paid to any lightning seen overhead during the height of a squall, or if St. Elmo's fires appear. Lightning can be divided into three forms, fork, sheet and ball (though fork and sheet are probably the same), fork lightning appearing as sheet when it is seen a long way off, only illuminating the sky. In the squall *cumulus* cloud the electrical displays take place in the upper part, and so are only seen before and after the squall. Ball lightning is rare; I have never seen or heard of it at sea.

10. *Remarks.*—Nothing is too trivial to be noted: peculiar ripplings or discolorations of the water and their causes (if possible); changes of wind

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[1] Surgeon-Major Black exhibited a good form of Marine Rain-gauge at the Exhibition of Instruments (p. 234).

and weather, with accompanying phenomena; icebergs, taken at the time they are in the neighbourhood of the vessel; frequent temperatures of the sea and air, with notices of any drift; solar and lunar halos and coronæ, with measurements of the diameters of the rings; any peculiar colouring of the sun or moon or clouds in their neighbourhood; dust in the rigging or on the water (the latter generally a minute weed, the *Trichodesmium Ehrenbergii*, which is frequently seen, and has undoubtedly been often entered as dust); birds, marine animals, fishes and weed, noting if the weed lies in lines in any particular direction, as the *fucus natans* does generally; notes on the zodiacal light, registering the stars to which the apex extends; if any great number of meteors be seen, the time of greatest number falling, with their radiant point, should be determined and noted; any comets seen should be at once fixed by measurements from three stars; unusual appearances in the sky, as auroras, should be watched and noted; unusual disturbances of the ship's magnetism should be watched, and the cause sought for. Observations with the spectroscope for the rain-band are interesting, and might eventually be useful. The rain-band is always more or less visible at sea. Observations on evaporation, the amount of ozone, and of carbonic acid gas in the air would be very valuable; but so many difficulties attend the experiments that they are not likely to be undertaken, except in special cases.

Mr. Scott's valuable *Instructions in the use of Meteorological Instruments* seem all that can be needed for land observers, but for those at sea something more is required than the few now issued. If my Paper should raise a discussion, from which some good rules may be framed, I shall be more than satisfied.

TABLE II.—SEA SURFACE.

Calm	0	Quite Smooth.
Very Smooth	1	Waves 0 to 1 ft. high.
Smooth	2	„ 1 ft. to 2 ft. high.
Slight	3	„ 2 ft. „ 3 ft. „
Moderate	4	„ 3 ft. „ 5 ft. „
Rather Rough	5	„ 6 ft. „ 10 ft. „
Rough	6	„ 10 ft. „ 18 ft. „
High	7	„ 18 ft. „ 28 ft. „
Very High	8	„ 28 ft. „ 40 ft. „
Tremendous	9	„ 40 ft. and upwards.

TABLE III.—VELOCITIES OF CLOUDS.

0 ...	No perceptible motion.
1 ...	Just moving.
2 ...	Moving slowly.
3 ...	Moving at moderate rate.
4 ...	Moving fast.

DISCUSSION.

Mr. **Abercromby** considered Capt. Wilson-Barker a careful observer, and that his suggestions were the result of practical experience. The only accurate way of ascertaining the direction of the wind at sea was to notice the ripple on the water. Capt. Wilson-Barker was quite right in recommending the use of tinted glass for getting the direction of cirrus cloud when the sun was shining. Rain might fall from a *cumulus* that was not cirrified on the top, either within or without the tropics.

Dr. **Tripe** did not agree with Capt. Wilson-Barker's remarks about lightning. He considered it impossible for sheet lightning to form zigzags. He was of opinion that forked lightning was really ball lightning. He had observed ball lightning some years ago on several occasions; had once seen three balls ascend one after another, at first slowly, diverging to the right and left alternately, ultimately the motion becoming quicker and quicker, until it formed what is known as forked lightning, appearing to the eye as a continuous flash. Observers have seen forked lightning to form a ball at the angles.

Capt. **Toynbee** said, that he was glad to find that Capt. Wilson-Barker, who is an "excellent" observer for the Meteorological Office, was considering the subject of observing on board ship; and he would read his paper with interest, and endeavour to get something from it which would improve the *Instructions* issued by the Meteorological Office. He would now confine himself to a few remarks on points which struck him as the paper was being read. It is the complaint of some that the Meteorological Office asked for too much already, so that an observation must have great practical value before it can come up to the Office requirements. With regard to anemometer observations on board ship, he was of opinion that these would cause much additional work, and would not be so trustworthy as the eye observations now recorded by the officer of the watch, using Beaufort's scale for the force, and the tops of the sea and motion of lower clouds over heavenly bodies for the direction. The *North Atlantic Synchronous Charts* now in the course of preparation by the Meteorological Office prove how very correctly steamers record the wind, as it often occurs that as many as ten steamers in the same part of the sea record the same direction of the wind to about a point, and nearly agree in its force. As to the placing of instruments, circumstances vary so much on different vessels, that it is found best to state the requirements in the *Instructions* and to leave it to captains to carry them out as best they can. They are, however, requested to record how they are placed, and, if possible, to make a change if the position is not supposed to be good.

Capt. **Toynbee** further said, knowing the difficulties to be overcome, he commenced working at meteorological observations with some doubt as to the value of the results to be obtained, but he was glad to say that the experience of twenty years had given him more and more evidence of their value, which is strikingly illustrated by the diagrams of Red Sea data exhibited on the present occasion. Separate diagrams have been drawn for records from three sources, viz. (*a.*) The data in the Meteorological Office; (*b.*) Data supplied by the Dutch Meteorological Office; (*c.*) The logs of the Peninsular and Oriental Company. There is a remarkable agreement in these results, more especially in the relative changes which depend upon geographical position. The cause of the specific gravity of the surface water of the Red Sea shows what very minute differences are detected by instruments of which Capt. Wilson-Barker complains that they are not sufficiently delicate for careful work. One of the comforting facts which is brought out by the discussion of sea observations is, that although a man's instruments may be badly placed, and do not record the *absolute* readings correctly, their circumstances remain much the same during the voyage, so that they give a very near approximation to the changes which occur.

Mr. **Symons** said, that regarding lightning, he was disposed to agree with Capt. Wilson-Barker's division of lightning into three forms, viz.: ball, forked and sheet, the two latter being practically the same, the difference in their appearance being due to the distance of the observer from the point of discharge, or the flash being behind a cloud. He believed that "ball" lightning was extremely rare at sea, and its nature was very little understood. The appearance of an ordinary lightning flash was now very well known, as the flashes had been photographed again and again. All the photographs showed a wavy undulating line, bifurcating or trifurcating at many points, and not bearing any resemblance to the angular line by which painters generally represented a lightning flash. He believed that sheet lightning and forked lightning were the same, for he knew of cases where so-called sheet lightning had caused structural damage to places at some distance from where it was observed as sheet lightning, and there could certainly be no damage without a stroke. The apparent 'line of fire' was possibly due to the transit of ball lightning at a high velocity, the impression left on the retina, when the motion was rapid, being that of a flash, just as with the old Catherine wheel, or a whirled burning stick.

Mr. C. **Harding** said that a pamphlet issued by the Meteorological Office, *Instructions for keeping a Meteorological Log*, contained hints for observers at sea which were in many respects similar to those put forward by Capt. Wilson-Barker. He thought that observers should adhere to one set of instructions, and not adopt their own methods, as uniformity of observation was a great thing to be desired, as well as similarity of instruments. He considered that the captain of a ship should be allowed to place his barometer in the position which best suited his convenience; but so far as the thermometers were concerned, the best place of exposure on board ship was a matter of considerable difficulty. Regarding the screening of thermometers, he said Mr. C. Chambers, in his work on *The Meteorology of the Bombay Presidency*, had given especial attention to the question of thermometer exposure, and his observations lead to the conclusion that in hot climates the thermometers cannot well be screened too much. He was of opinion that the cloud classification proposed by Capt. Wilson-Barker would be inconvenient to adopt. A comparison of the Meteorological Office Logs with those of several Steamship Companies had been carried out in the Meteorological Office, and the agreement of the results from these different sources was very good. He thought that often a steam ship offered greater advantages for the purposes of meteorological observation than a sailing vessel, as the former was usually better officered, and, as far as ocean currents were concerned, was better able to give a correct dead-reckoning position.

Capt. **Wilson-Barker**, in reply, said that his Paper was intended to suggest more uniformity in the position of instruments and method of taking observations on board ship. He thought it most important that the instruments should be near the bridge for the convenience of officers. The *Instructions* at present in existence were not complete enough for general guidance.

MARINE TEMPERATURE OBSERVATIONS.

By HUGH ROBERT MILL, D.Sc., F.R.S.E., F.C.S.

(Communicated by J. W. Tripe, M.D., Secretary.)

[Read March 16th, 1887.]

The problem of ascertaining the temperature of the depths of the ocean is no new one, and as yet it has not been by any means satisfactorily solved. This paper is intended to be purely practical, and I do not propose to describe historical developments, although the history of marine physical research is most interesting and full of lessons for the modern observer.

The immediate object of observing temperature beneath the surface of water is to ascertain the vertical distribution of warmth at a definite place and time. This has been attempted since the days of Hooke and Boyle by raising water from the desired depth in a valved box, and observing its temperature when it comes on board. Probably the most recent application of such an arrangement was by the late Sir Robert Christison, in the course of his work on Loch Lomond in 1872. Bottom temperatures may be obtained very exactly, as was pointed out long ago, by raising a sample of mud or ooze and plunging the thermometer into it. The first great impulse to marine temperature observations was given by H. B. de Saussure, who introduced, about 1770, the use of a very sluggish spirit thermometer, the bulb of which was protected from pressure by a strong wooden box containing a mass of non-conducting material. This was immersed for many hours, and changed its temperature so slowly that no appreciable alteration was produced by drawing it up through any depth of water, at any temperature likely to be found in practice. Saussure's work is admirable for the care with which it was carried out, and his results may be relied upon. The worst defect of his process was its tediousness. In 1804, Peron, by means of a thermometer protected by successive layers of air, glass, charcoal, wood, tallow and resin, made many soundings down to about 400 fathoms in equatorial seas, and finding the temperature continually to decrease to that depth, he pictured an ocean, frozen at the bottom, surrounding a world the core of which was eternal ice. Sluggish thermometers are still occasionally employed.

When Cavendish and Six invented their registering thermometers, towards the close of last century, the important applications of these instruments to marine work were at once recognised, but the difficulty of guarding against pressure long proved a stumbling block, preventing their employment at great depths and falsifying the results for shallower soundings. Cavendish, indeed, proposed to leave his thermometer tube unsealed, a very significant idea, as we shall afterwards see. The attempts to screw up a thermometer in a metal case strong enough to resist the pressure of over a thousand fathoms of water were never successful, and not until the introduction of thermometers with double bulbs were trustworthy data obtainable from great depths. The pattern of protected Six's thermometer used on the *Challenger* is a type of this form of deep-sea instrument.

The successful use of any maximum and minimum registering thermometer depends on the assumed fact that the temperature of water varies uniformly with depth. When each successive thermometer, after being immersed for a sufficient time, shows a temperature lower than that above it, the inference is a fair one that there is an unbroken fall of temperature from surface to bottom. When the fall proceeds to a point beneath which the readings of all the thermometers are the same, it is presumed that below the minimum there is a regular and uniform distribution of temperature throughout the mass. In cases where the surface water is much chilled by floating ice or other causes, there is a sub-surface maximum which may indeed be detected in certain circumstances by these thermometers, but the limits of which cannot be defined by them. Great assistance is, however, afforded by the use of the piezometer, an instrument in which there is no attempt to prevent pressure from influencing the volume of the thermometric fluid, but where, on the contrary, every facility is given for it to do so. The mercury piezometer, as devised by Mr. Buchanan on the *Challenger*, and used by him during the latter part of that memorable expedition, is simply a very large thermometer, the bulb of which is filled with mercury. The tube contains a column of water with a steel index included, and, after being bent twice at right angles, it dips into a mercury cup. Increase of pressure tends to force mercury from the cup up the tube, increase of temperature to force it back again, each to an extent depending on the difference of compressibility and expansibility of mercury or water and glass. Thus the position occupied by the index of a piezometer after an excursion to a great depth depends on the pressure and the temperature; and the pressure is a function of the depth and average specific gravity of the water. If any two of the three quantities, depth, specific gravity and temperature, are known, the value of the third is given by the piezometer reading. Thus, in many cases, though not universally, the temperature at a given point can be ascertained. Unfortunately the piezometer was not applied to this purpose on board the *Challenger* until after she had completed her Antarctic observations and the survey of the deep enclosed seas of the Eastern Archipelago, two regions in which additional certainty is much to be desired.

All instruments with moveable indices are liable to suffer change of record from the jars and strains to which a very long sounding line worked from a ship is always exposed. This may be reduced in several ways; for instance, by the use of accumulators to suspend the tail block, and by attaching the thermometers to the line by stout pieces of india rubber, a slack lanyard being also used to hold the thermometer should the rubber give way. This source of error can never be entirely overcome. In addition to these essential drawbacks, the *Challenger* thermometers had other defects. The degrees were short, and were not engraved on the stem, so that uncertainty was introduced from parallax in referring the ends of the indices to the attached scale; readings could, in fact, only be attempted to quarter degrees Fahrenheit. Mr. Buchanan introduced a number of improvements; he made the instrument larger, reduced the bore on the minimum side and increased it on the maximum, thus giving very long degrees where they were most wanted, and a great range for high temperature, so that the index might not be carried into the upper bulb by accidental overheating. An arbitrary graduation in millimetres, etched on the tube, enabled very accurate readings to be made, the corresponding temperatures being given by a calibration table. Thus modified, the Miller-Casella thermometer is an instrument of precision, and results of the utmost value may be expected from it, such as were obtained, for instance, by Mr. Buchanan on Loch Lomond in the autumn of 1885. Certain improvements as to the manner of attaching the outer bulb have been suggested by Professor Tait in his *Challenger* Report on the pressure correction, and when these are carried out, no correction whatever will require to be applied for pressure, even for the deepest oceanic abysses.

Thermometers with moveable indices, or even fine bore maximum thermometers on Phillips' principle, which have been used for observations in wells, may give satisfactory results when lowered and raised carefully by hand in moderate depths of calm water, and yet be utterly misleading when they are used in a deep or rough sea, and worked by a steam winch.

A thermograph, protected for pressure, and sunk very slowly, would be an ideal instrument for recording deep-sea temperature; but, failing this, the best thing is to employ a thermometer capable of registering precisely the actual temperature at a given depth. A thermo-electric junction might be used for this purpose, and the temperature ascertained from the readings of a galvanometer on board. Siemens' Electrical Thermometer might be employed. It consists of two precisely similar coils of insulated wire on opposite sides of a Wheatstone's Bridge, and traversed by the same current. One coil is sunk to any depth by stout insulated wires, and its resistance is altered by the change of temperature. The second coil, retained on board, is immersed in water, the temperature of which is varied by the addition of ice until electrical equilibrium is restored, and then the exact temperature ascertained by means of a delicate thermometer. The former method is inapplicable, at any rate to small vessels, and even the latter presents so many difficulties that its use was not persevered with on the *Challenger*.

In 1845 Aimé made important researches on the temperature of the Mediterranean by means of a special arrangement of outflow thermometers which it is unnecessary to describe in detail. They possessed certain great advantages, but required very careful manipulation to give good results. The instruments were arranged to register during ascent or descent, and to cease or commence registering, on being inverted by means of a weight slipped down the line from the ship. By using two such instruments, the respective sums of all rises and falls of temperature between the surface and a given depth were ascertained, and thus, by a simple calculation, the temperature at that depth. Although Aimé's observations were extremely interesting and valuable, I do not know that his apparatus was ever employed by other observers.

The principle of the outflow thermometer has been modified in an ingenious manner by Messrs. Negretti and Zambra, who have ultimately produced in their patent standard deep-sea thermometer an instrument of the greatest value for marine temperature observations. The old form, in which the siphon-shaped tube had to be turned through a complete revolution, was not very successful on account of the complexity of the reversing gear; but the half-turn instrument now in use answers all reasonable requirements. This thermometer hardly requires description. It is filled with one liquid, mercury, and just above the bulb the tube is contracted and then swelled out into a small pouch or chamber. In an upright position the thermometer acts like any other, but when it is inverted the mercury column breaks off at the contraction and runs into the tube, which is graduated so as to be read in the inverted position. The whole thermometer is sealed up in a strong glass tube, to protect it against pressure, and the bulb is surrounded with mercury to transmit the heat rapidly. After the thermometer is inverted, the record of temperature remains unchanged, except for the slight expansion or contraction of the broken-off column by change of temperature. I have lately made experiments on the temperature correction of eight of these thermometers, and found as the average of a number of trials that a change of 60°

lengthened the broken-off column by 1° of the scale, the temperatures employed being 32° and 92°. Hence for a change of 6° between the temperature of reversing and that of reading a correction of one-tenth must be applied. The practical application of this is difficult. In summer, for instance, a thermometer reversed at 45°, hauled up rapidly, and read in air at 65°, might appear to require a correction of −0°·3; but, recollecting that the thermometer is read before it has time to assume the temperature of the air, and that it is wet, we see that the amount of correction should be considerably less. If the thermometer is hung up in the wind for five minutes, and kept wet all the time (for it would be impossible to dry it thoroughly), the wet bulb temperature of the air, ascertained by a sling thermometer, might be used to correct the readings. Or, more simply, the inverted thermometer may be placed for a few minutes before reading it in a bucket of surface water, the temperature of which can easily be noted, and the corresponding correction applied. In our latitudes the temperature of air and sea are usually so near together that a correction so great as 0°·3 has very rarely to be applied, but in the tropics the case is very different. For instance, if under the equator a thermometer is inverted at 35° at the bottom, drawn up gradually through water warming to 85° at the surface, and finally read in air at 95° or more, a correction of at least 1° would be necessary. In most of the thermometers I have examined the pouch-shaped recess is not large enough to contain the overflow from the bulb when the temperature is raised 60° or more after inversion; and in other cases, although the pouch is large enough to hold the overflow, a very slight jerk is sufficient to carry it past the siphon bend, and so vitiate the record. This is a mere mechanical defect, and will doubtless be seen to in the event of such thermometers being ordered for tropical work. The observers on the recent North Sea Expedition in the *Drache* satisfied themselves that the probable error of such thermometers was about 0°·2 C., but in the work of the Scottish Marine Station it was found safe to rely on the readings to 0°·1 F.

The glass-encased thermometer is fixed by means of thick india rubber rings and washers in a perforated brass case, and the Germans found that these rings tended to make the instrument somewhat sluggish in its action. I have not noticed this effect, but probably Sigsbee's method of packing, used by the United States Fish Commission, would be found more convenient and satisfactory than that employed in Europe. It consists in the substitution of spiral springs pressing on the end plates of the brass case, and supporting the thermometer firmly, but with sufficient elasticity to neutralise the effect of jars on the line.

The question of the suitability of the Negretti and Zambra Thermometer for exact work being settled, there remains the important matter of insuring its inversion at the wished for depth. I have never used the original wooden float with shot counterpoise, nor do I think that very satisfactory results attended its employment. Magnaghi's frame was a marked improvement. The thermometer mounted on trunnions is held upright in the frame by a pin, which is raised by the action of the rush of water past a screw propeller on the instrument being drawn up. At first there were two blades on the propeller, but the addition of a third gave it much greater cetairnty in working. When the thermometer falls over, it is clamped by a side spring, and retained in its inverted position until reset. A light india rubber band passed round the upper part of the frame insures the reversal taking place immediately on the pin being withdrawn. The Magnaghi frame in its original form, and with the addition of many modifications, has been largely used for deep-sea work, and has given considerable satisfaction. The work of the Scottish Marine Station in shallow water and amongst rapid currents revealed a number of defects in this frame. When it was set so as to reverse when hauled up through less than 1 fathom, it was often set off by the pitching of the ship or by the force of the current, and when adjusted for a longer haul, the exact depth at which it turned over could not be ascertained, and it was impossible to get bottom temperatures. The method of attachment to the sounding line by lashings was also found to be troublesome and slow, especially in cold and wet weather. The Scottish frame was accordingly devised. It is a modification of Magnaghi's, the screw pin with its revolving gear being replaced by a simple pin actuated by a lever, which is depressed by a weight, slipped down the line, striking on the forked outer branch. A vice-clamp serves to fix the frame to the sounding line at any point. The final form of frame was not arrived at until after many experiments, but several thousand observations have now been made with it, and have shown it to be convenient and trustworthy.

The United States Fish Commission used on the *Fish Hawk* a frame adapted for a wire sounding line, and in it reversal was determined by the fall of a brass weight. They also employ the Magnaghi frame, with a special clamp—the Tanner—for attaching it.

Captain Rung, of Copenhagen, has an extremely simple and ingenious reversing arrangement made of wood, and also actuated by a messenger striking a spring hook. Rung's messenger is extremely ingenious, made in two parts which can be fitted together on any part of the line, thus saving the trouble of reeving. These are used also for the Scottish frame, and have given the utmost satisfaction.

The importance of having thermometers which can be made to register at any given depth is very great. For instance, the temperature of the surface of Loch Strivan was 42°·0 in February, at 5 fathoms 42°·1, at 10 fathoms 44°·4, at 15 fathoms 45°·0, and at the bottom (35 fathoms) 44°·1. Closer observations showed that at 8 and 9 fathoms the temperature was 42°·1, while at 9½ fathoms it was 44°·4, showing a rise of 2°·3 in 3 feet, and a change of only 0°·1 in the whole 54 feet above. In shallow estuaries I have frequently found almost all the change of temperature between surface and bottom to take place in a few inches of depth. In such cases, Magnaghi's frame would be of no service. In the deep sea, however, where depths are counted, not by tens, but by thousands of fathoms, and in which the employment of messengers on the line would be very tedious, the Italian frame is probably the best, although the pressure-plate reversing gear of the

Challenger stop-cock water bottle might be simpler. An electrical arrangement for reversing the thermometers, if such could be adapted to a deep-sea line, would be much better. In the French *Travailleur* Expedition a wire attached to the sounding rod was used to invert the bottom thermometer.

Using a small boat, it is possible for the observer alone—with a boatman to keep the vessel in position—to work a 120-fathom line and read the thermometers quite satisfactorily. It is convenient in such a case to use only two thermometers. The first is set and placed a few feet above the lead, which may be very light in still water but must be heavy if there is a current, lowered over the side, and the second thermometer attached of 5 or 10 fathoms or feet, as the case may be. The second thermometer is set, and a messenger, previously clasped on the line, hung to it by a wire or cord, the whole being then lowered to the proper depth. The line is secured, and the interval of exposure may be taken advantage of by observing the air temperature, at first with the dry-bulb sling-thermometer, if rain is not falling, then with the wet. Three minutes having elapsed, a messenger is clasped on the line and let go; the impact is distinctly felt in a few seconds, and that of the second messenger, released by the stroke of the first, is felt a little later. The line may then be hauled up, the thermometers set upright in the boat without being detached from the line, then read carefully, set, and lowered again to different depths.

On a larger vessel a steam winch is a great convenience. On the *Medusa*, the steam yacht of the Scottish Marine Station, the sounding line is coiled on a drum and passed through leading blocks to a tail block on a derrick, which projects slightly over the side near the bow, at a height of 8 feet from the deck. The ship is stopped, one man stationed at the wheel, with the engine reversing-gear within reach, keeps her head to the sea with the line as nearly perpendicular as possible on the windward side. Should a sounding be made on the lee side, the vessel is likely to drift over the line, and occasion much trouble in getting clear. A slip water bottle is fixed on the line, just above the lead; 2 feet above that—so as to be 1 fathom off the bottom—a thermometer is clamped on and a messenger hung to it, in order to close the water bottle. The whole is then lowered 10 fathoms, another thermometer and messenger attached, the process repeated once, or twice if four thermometers are available, and the line is lowered until the lead strikes the bottom. In calm weather it is allowed to remain thus; but when there is any sea on, the depth is recorded, and the line raised 1 or 2 fathoms, to prevent bumping. A messenger is let go after three minutes; and as soon as the impact of the last messenger on the water bottle is felt, the steam winch is put in motion, and the line rapidly hove up. As each thermometer appears it is removed, the winch being stopped a moment for this purpose; the reading can be made and recorded by the time the next instrument comes to the surface. When the water bottle comes up a sample is bottled for chemical analysis, and the thermometers are replaced in the same order as before, and the process repeated again and again, until an observation has been made at every 10 fathoms from surface to bottom. Then the figures recorded in the observation book are examined, and if there is any sudden difference between two, or any unusually close agreement, readings are made at intermediate depths, and this process of subdividing spaces may be carried on until the exact form of the temperature curve has been ascertained. With a crew of three men an observer can, in a quarter of an hour, make and record six observations; that is to say, two dips of the sounding line with three thermometers, and also observe the air temperature, barometer, wind, weather, &c. This may be contrasted with the time required to get the same number of observations with spirit thermometers.

To read a thermometer graduated to whole degrees to tenths is somewhat difficult at first, when the vessel is pitching or rolling much; but after a little practice it can be done easily. The error induced by parallax may be overcome very simply by holding the thermometer so that the graduation mark nearest the top of the column exactly covers its own reflection in the mercury.

Recording the observations is more difficult. For boat work, particularly at night and during rain, when the observer is alone, I have found it most convenient to write with a glass style on a common school slate, covered with a layer of wax. The observations may be copied at any time, and the slate restored to its original state by gently warming it. It is, however, a matter of considerable importance to preserve the original records. When the observer must both read the instruments and mark down the results his wet hands soon make an ordinary note-book useless, especially when there is wind and rain or snow. In such circumstances I have used a leather case containing cards with a printed form for all the data required; this can be shut and kept in the pocket between observations. As each card is filled it may be slipped under the rest, and is thus protected from rain. When the cards of a trip have been copied into the permanent record book, they can be kept conveniently for future reference in little boxes or pigeon holes. When it is possible, there should be an assistant to write down the figures as the observer reads them from the instrument, and in such a case an observation book of good paper and strongly bound is perfectly suitable. On each page spaces are printed for the various data of weather, position, &c., and a line reserved for the temperature at each 1, 2, or 5 fathoms, down to the greatest depth likely to occur. The pages not in use are secured by an India rubber band, so that the book opens only where it is wanted, and the wind cannot turn over the leaves.

So far the mere observations have been considered, and it is hardly the province of this Paper to include the equally important matter of discussing results; but a few words may be added on the subject. Graphical methods should be used as much as possible, and the first of these is the drawing of station curves. Depth and temperature being taken as co-ordinates, the curve should be drawn as a series of straight lines joining points; for, unless good reason exists for suspecting a particular observation, one is not justified in leaving it on one side, because to include it would spoil the regularity of the curve. As a rule the temperature curves for vertical distribution in shallow water (down to 110 fathoms) are not regular, at least for sea-water near land. During a year's work in the water of the Clyde sea-area a great number of instances have occurred in which warm and cold layers were found one above the other, giving a serpentine appearance to the resulting curve. From the station curves temperature sections should be constructed, a profile of a portion of the region under examination being drawn and the isotherms laid down on it. For the sake of appealing to the eye these should be coloured, and since one temperature merges into another, the corresponding colours ought so to merge. The order of colours in the spectrum seems the most natural. I have drawn a number of sections in which the highest temperature is shown by red, the lower ones by orange, yellow, green, blue and violet. From the sections the mean temperature from surface to bottom along the whole range may easily be calculated, and the mean temperature at various periods during an entire annual cycle, when plotted in a curve, give a much more general view of heat variations in water than a similar curve for water at one station and at one depth. Many interesting relations come out more clearly by plotting the curves of cycles, not by cartesian, but by polar co-ordinates, the radius measuring temperature, the angle time.

In conclusion, it may be well to enforce once more the extreme importance of marine temperature observations. The thermometer can not only reveal many new facts regarding the mutual heat transactions of air and water; it has been converted into an instrument of geographical, at least of hydrographical research, the most conspicuous instance near home of this application being the discovery of the Wyville-Thomson Ridge in the Färoe Channel. The thermometer may also be used in navigation for warning the sailor of the proximity of icebergs, or of land, or of certain currents; it is of the utmost importance, especially at certain times of the year, in tracing out the interaction of river and sea water in harbours and estuaries. Facts are gradually being accumulated which may lead to the discovery of relations between temperature and animal life in the sea; such relations would be of vital importance in the proper management of fisheries. For this last reason alone, considering the vast extent of the North Sea fisheries, we ought to have some knowledge of the temperature conditions of that sea. As yet there only exist the records of the scientific cruises of two German war ships in the summer months of one or two years. I do not know of any trustworthy temperature observations made beneath the surface of the North Sea during winter.

DISCUSSION.

Capt. **WILSON-BARKER** said he had listened with great interest to this Paper, which had dealt with a very difficult subject, but he was of opinion that no really accurate results would be obtained until there were some means of getting a continuous register of temperatures as the lead descends, which could only be obtained by electrical instruments. A number of thermometers attached at intervals to a grapnel rope is a good way of obtaining temperatures at given depths, but it takes up too much time. He said that the United States Signal

Corps have recently brought out a revolving psychrometer stand, the whole apparatus to be revolved by means of a handle before taking the observation.

Capt. **Wharton** said he hoped that the result of the patient and useful investigations which were being carried on at the Scottish Marine Station would lead to great improvements in the instruments used in marine research. He had used Negretti and Zambra's earliest pattern of turnover thermometer, and had found that it worked very well at first, but after the wood became sodden with water by continual use, the instrument became unreliable, and its indications were unsatisfactory.

Mr. **Willis Bund** asked whether Dr. Mill could give any information regarding temperature observations in river estuaries. A few observations had been made in the Estuary of the Severn, and it had been found that there was a great difference in the temperatures at high and low water respectively. There was, however, considerable difficulty in having reliable observations taken at one place for any considerable time.

Dr. **Mill** said he could not give very much information in answer to Mr. Willis Bund. In the Forth Estuary the tidal disturbance of temperature was slight. In summer the river water was warmer than the sea, and in winter the sea water was warmer than the river. They had no river estuary in Scotland which resembled the Severn, the only large estuary on the west coast being that of the Clyde, but this opened to the south, and the tidal effect on it was very much less than on the Severn.

THE STORM AND LOW BAROMETER

Of DECEMBER 8th and 9th, 1886.

By CHARLES HARDING, F.R.Met.Soc.

[Read April 20th, 1887.]

The Storm which swept across the British Islands on December 8th and 9th, 1886, was one of the most violent disturbances experienced of late years, the force of the wind attaining unusual strength, and the duration of the gale being very prolonged. The barometer fell to a very low level, a lower level indeed in Ireland and in the northern and central parts of England than has previously been recorded, and the mercury remained low for a longer period than usual in our ordinary gales. The extent of the gale was also very considerable, embracing nearly the whole area of Western Europe from Norway to Spain. In many ways the storm may lay claim to being considered one of the first magnitude.

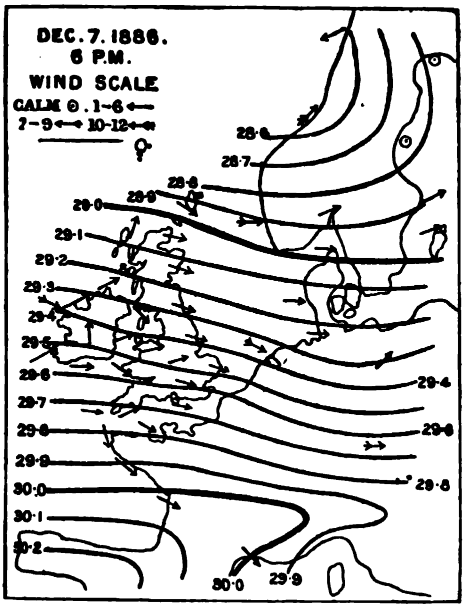
Prior to the setting in of this storm the weather had been in a very disturbed condition over the British Islands, and deep depressions had been skirting the north of Scotland. The chart prepared by the Meteorological Office for 8 a.m. on December 7th shows that the barometer was falling over the whole of Great Britain, under the influence of a large depression in the north, the centre of which was now situated over the North-west of Norway. In the east of England the wind was still blowing from the South-west and West, but in the western districts it had veered to the North-westward, whilst in Ireland the wind had not only veered but the barometer was also rising.

At Valencia, however, the wind was blowing from the West-south-west, which seemed to indicate the approach of a secondary disturbance.

At 2 p.m. the wind was nearly everywhere North-westerly and the barometer had risen since the morning, except in the extreme west of Ireland, where hail and rain squalls were being experienced. At Valencia the barometer had fallen 0·02 in. since noon, but the wind had now veered to the North of West. The trend of the isobars was from North-west to South-east over the whole country, and in good agreement with the North-westerly current of air which was blowing.

At 6 p.m. the barometer continued to rise in the east of Scotland and England, but in all other parts of the British Islands the mercury was falling, and at the most western stations the fall was now somewhat brisk, amounting to 0·17 in. at Valencia since noon, or at the rate of about 0·03 in. per hour. The isobars ran nearly due east and west over the whole country, and if it were not for a knowledge of the fact that the barometer was falling briskly in Ireland, the appearance of the chart drawn from the observations at this hour (Fig. 1) shows that it would have been bold in the extreme to have anticipated the near approach of bad weather. The deep depression, with the barometer down to 28·6 ins., was stationary over Scandinavia, whilst the high barometer, 30·35 ins., still remained over Spain. In the extreme north of Scotland the reading of the barometer was 29·0 ins., and in the south of England it was 29·7 ins., giving a total difference of 0·7 in. in 500 miles (geographical), or a gradient of 0·02 in. for 15 miles. The barometer at Valencia at this time

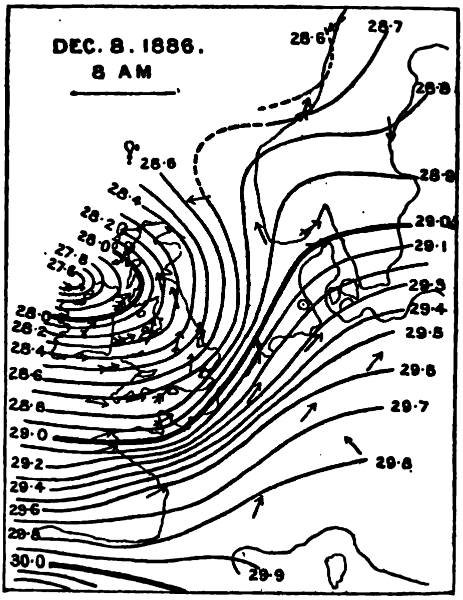
FIG. 1.



was 0·04 in. higher than at Yarmouth, and there were absolutely no gradients for Northerly and Southerly winds over the whole country.

The chart for 8 a.m. on the 8th (Fig. 2) shows an enormous, and most important, difference. A large and very deep depression had arrived from off the Atlantic, and its centre was at this time situated off the north-west coast of Ireland, the barometer at Belmullet reading 27·58 ins., and the wind there was blowing with hurricane force from the West-south-west. The fall of the barometer during the night was exceedingly rapid over the whole of the United Kingdom, and the increase of wind was equally sudden. Table I. shows the changes which occurred between 6 p.m. on the 7th and 8 a.m. on the 8th, at a few stations selected to represent the British Islands fairly.

FIG. 2.



The barometer changes are given in inches, and the wind force in units of Beaufort Notation—0 to 12.

The distribution of atmospheric pressure was quite different to that shown on the chart of the previous evening (7th, 6 p.m.), the trend of the isobars being now for South-easterly winds over Scotland, and for South-westerly winds over England, Ireland, and France. The steepest gradients were in the west of Ireland, where the difference of barometer readings was 0·7 in. in 110 miles, or a gradient of 0·09 in. in 15 miles. Measuring from the central area of the disturbance, off the north-west coast of Ireland, the difference of pressure in a north-easterly direction was 1 inch in 360 miles, in an easterly direction 1 inch in 400 miles, in a south-easterly direction 1 inch in 350 miles, and in a southerly direction 1 inch in 210 miles. The greatest difference

TABLE I.

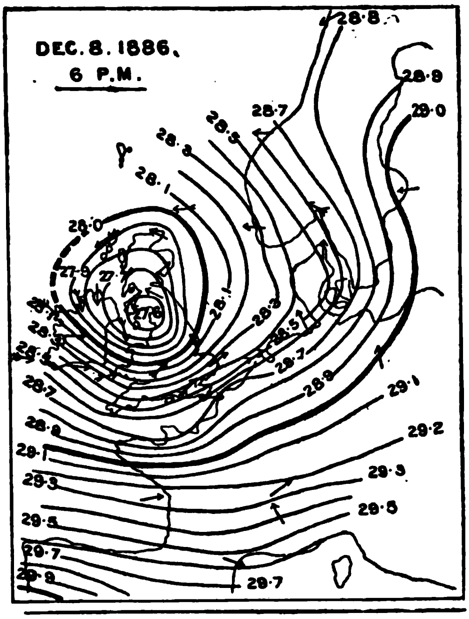
Station.	Belmullet.	Malin Head.	Holyhead.	Ardrossan.	Valencia.	Oxford.	Hurst Castle.	Scilly.	London.	Leith.	Stornoway.	Yarmouth.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
Fall of barom. in 14 hrs. from 6 p.m. 7th to 8 a.m. 8th..........	1·76	1·50	1·37	1·24	1·20	1·05	1·01	0·97	0·97	0·97	0·80	0·73
Rate of fall per hour	·13	·11	·10	·09	·09	·08	·07	·07	·07	·07	·06	·05
Wind at 6 p.m. 7th	WNW 7	SW 3	WSW 5	Calm	SW 4	SSW 3	WNW 6	W 6	WNW 3	W 2	SSW 3	WNW 5
Wind at 8 a.m. 8th	WSW 12	S 4	WSW 9	SW 6	WSW 10	SSW 9	SW 11	W 11	S 8	SE 5	E 9	S 8

between any two stations in the British Islands was 1·31 ins., the readings being respectively 27·58 ins. at Belmullet and 28·89 ins. at Dungeness, which gives an average gradient of 0·04 in. in 15 miles. The same gradient of 0·04 in. in 15 miles was shown over a distance of 900 miles, between Belmullet and Corunna, the reading at the latter station being 30·22 ins., and giving a total barometric difference of 2·64 ins., a variation equal to about one eleventh of the average total weight of the atmosphere. In connection with this single depression a gale was blowing over the whole tract from Stornoway in the north to Corunna in the south, a distance of more than 1,100 miles. The force of the gale at this time was exceptionally severe over Ireland, and the central and southern districts of England, as well as over a large part of France.

At 2 p.m. the disturbance had advanced to the eastward, and its centre was situated over the north of Ireland; the barometer had continued to decrease in the north, south, and east, but a recovery had already set in in the west, and the mercury at Belmullet had risen 0·23 in. since 8 a.m. The wind continued with hurricane force at many stations, and the violence of the gale had greatly increased in Scotland.

At 6 p.m. (Fig. 3) the centre of the disturbance was near the Solway Firth, and about midway between Ardrossan and Barrow-in-Furness, at both of which stations the barometer read 27·62 ins. The depression had travelled somewhat rapidly across the north of Ireland and the Irish Sea, apparently

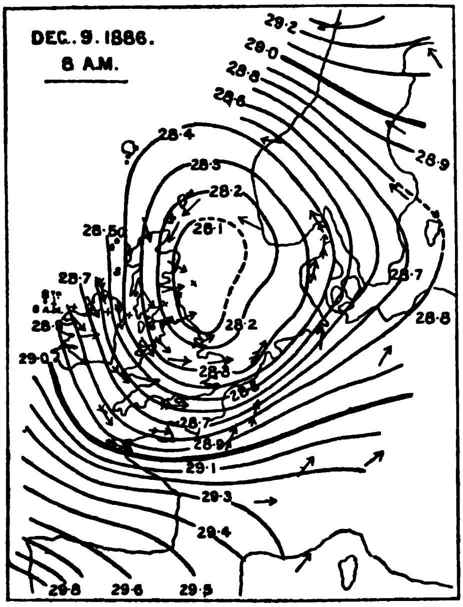
FIG. 3.



at the rate of about 25 miles an hour, in a direction almost due east. The area of the storm had extended since the morning, and it was now blowing a strong gale in Denmark and Norway. The difference of the barometer was fairly equal in a south-easterly, southerly, and south-westerly direction from the storm centre, amounting to 1 inch in 240 miles or a gradient of 0·06 in. in 15 miles, whilst in a north-easterly and northerly direction the gradient was only about one-half as great, and to the westward of the centre the gradient was 0·04 in. to 15 miles. The force of the wind was even stronger than shown in the earlier charts, and to the south of the centre, over the southern districts of England, the Channel, and France, hurricane force was commonly reported. Rain was falling pretty generally in each segment of the storm, and squalls were recorded at nearly all stations to the south of the storm-centre, both in the front and rear of the storm's path, whilst thunder and lightning were limited to the south-east part of the storm area, and were not noted nearer than 250 miles from the centre of the disturbance. The wind over the whole of Ireland, which was now in the rear of the storm, had veered to the North-westward. The high pressure area over Spain had decreased somewhat since the morning, the barometer at Corunna having fallen 0·16 in., and the wind at that station had increased to a strong gale from the South-west. The area over which the storm was blowing with the force of a gale at this time was nearly 850,000 square miles, and the area enclosed by the isobar of 28·0 ins., that is, with readings below 28 inches, was 181,000 square miles (geographical).

The chart for 8 a.m. on the 9th (Fig. 4) shows that the centre of the disturbance had passed to the eastward of Great Britain, as it was now situated at about 80 miles to the east of Aberdeen. Since 6 p.m. on the 8th the progress of the storm was considerably slower than when first reaching our Islands, and its rate of travel was apparently now rather less than 15 miles an hour, and the depression was rapidly filling up, the lowest isobar being only 28·1 in., although possibly the barometer may have been slightly lower, to the extent of a tenth of an inch or so, if readings could have been obtained over the North Sea. The wind still maintained the force of a gale over the British Islands, as well as over a very large area of the continent of Europe, but there was a decided decrease in its strength. The lowest reading of the barometer at this time was 28·06 ins. at Shields, whilst at Corunna the mercury was 30·01 ins., the difference giving a gradient of 0·08 in. in 15 miles. A gale was still blowing at places over the whole area, but the wind had lulled down considerably, especially in proximity to the central area of disturbance.

FIG. 4.



The charts for 2 p.m. and 6 p.m. show that the depression was still filling up and the gale was gradually subsiding, although at some few places it still blew with the force of a strong gale. At 6 p.m. the central area was steadily traversing the North Sea, and was within 50 miles of the coast of Norway, travelling nearly direct for Skudesnaes, where the barometer was reading 28·28 ins., the lowest on the chart.

On the 10th the gale had completely spent itself, and the depression which was still over the south of Norway and Sweden was rapidly filling up, the lowest barometer reading towards the close of the day being 28·9 ins., or about 1·5 in. higher than forty-eight hours previously.

The very rapid way in which the first fall of the barometer for this gale was propagated is shown in Table II., which also gives a few other details which may be of interest in connection with the storm, from stations having self-recording instruments.

TABLE II.

Stations.	Barometer.					Wind.			
	Fall commenced.	Minimum.		Hours below		Date.	Direction.	Velocity.	Hours above 30 miles an hour.
		Date.	Reading.	29 ins.	28 ins.				
			Ins.						
Valencia	7th, 10 a.m.	8th, 9 a.m.	28·32	34	..	8th, Noon	W	72	33
Kilkenny	„ 4 p.m.	„ 3 p.m.	27·96	42	4	..	..	..	..
Scilly....	„ 4 p.m.	„ 3 p.m.	28·62	34	..	„ 3 p.m.	NWbW	71	49
Falmouth	„ 4 p.m.	„ 6 p.m.	28·59	34	..	„ 5 a.m.	SSW	61	39
Fleetwood	..	..	..	..	..	9th, 9 a.m.	SW	80	65
Stornoway	„ 1 p.m.	„ 5 p.m.	27·90	62	10	..	..	..	..
Aberdeen	„ 7 p.m.	„ 8 p.m.	27·78	61	18	8th, 10 a.m.	SE	59	5
Kew	„ 7 p.m.	9th, 5 a.m.	28·31	40	..	„ 7 a.m.	S	42	21
Yarmouth	„ 8 p.m.	„ 1 a.m.	28·16	48	..	„ 9 a.m.	SbW	54	16

The above details are merely given that some of the principal elements which constitute a severe gale may be seen side by side, but the storm was of such an exceptional character that I have thought it advisable to give the tabulated values of barometer and wind in greater detail.

Table III. gives the hourly readings of the barometer, reduced to sea level, at several stations selected to represent fairly the British Islands.

Table IV. gives in a similar way the miles per hour travelled by the wind.

The anemometrical observations show that the wind increased to a moderate gale (40 miles an hour) at Valencia at 10 p.m. on the 7th, Holyhead at 1 a.m., Scilly and Falmouth at 2 a.m., and Fleetwood at 4 a.m. on the 8th; whilst at Shields and Yarmouth the force of a moderate gale was not reached till 7 a.m. on the 8th. The returns from the lighthouses and lightships around the coasts fully confirm this. At the Kish Bank the wind increased to a moderate gale at midnight on the 7th, and at 1 a.m. on the 8th it was blowing a strong gale. At the Blackwater Bank the wind increased to a gale from South-west at 2 a.m. on the 8th. During the storm secondary depressions were skirting to the eastward in the southern segment of the storm-area. It was the passage of one of these which caused the sharp hail squall with thunder and lightning which passed over London at 9 a.m. on

TABLE III.—OBSERVATIONS BY SELF-RECORDING BAROMETERS.

Time.	Valencia.	Kilkenny.	Stornoway.	Aberdeen.	Glasgow.	Hodsock.	Great Yarmouth.	Berkhamsted.	Kew.	Wallington.	Clifton.	Falmouth.	Scilly.
Dec. 7th.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
10 p.m.	29·11	29·30	29·02	29·12	29·16	29·41	29·49	29·55	29·58	29·57	29·55	29·57	29·58
11 ,,	28·95	·18	28·99	·09	·11	·38	·46	·52	·55	·53	·53	·49	·51
Midnt.	·75	29·04	·95	·06	29·05	·35	·44	·47	·50	·50	·46	·43	·40
8th.													
1 a.m.	·59	28·84	·90	29·02	28·98	·28	·38	·39	·44	·42	·37	·30	·30
2 ,,	·57	·63	·84	28·96	·91	·25	·33	·34	·36	·36	·24	·17	·15
3 ,,	·56	·50	·78	·93	·81	·18	·28	·24	·28	·26	29·10	29·01	29·02
4 ,,	·51	·47	·67	·83	·65	29·08	·18	·14	·16	·16	28·95	28·88	28·90
5 ,,	·47	·43	·61	·76	·51	28·93	29·05	29·02	29·06	29·03	·78	·77	·85
6 ,,	·43	·40	·51	·65	·33	·78	28·92	28·88	28·94	28·89	·65	·75	·81
7 ,,	·40	·36	·38	·53	·18	·62	·79	·75	·80	·73	·63	·74	·79
8 ,,	·36	·32	·32	·42	·08	·43	·69	·63	·66	·61	·62	·73	·77
9 ,,	·32	·26	·27	·30	28·03	·35	·60	·58	·64	·60	·61	·73	·76
10 ,,	·33	·19	·17	·18	27·99	·34	·53	·56	·58	·59	·60	·71	·75
11 ,,	·36	·11	·10	·09	·96	·33	·49	·55	·57	·57	·58	·70	·73
Noon	·35	28·01	28·03	28·00	·90	·32	·46	·52	·54	·52	·55	·66	·71
1 p.m.	·36	27·98	27·97	27·94	..	·26	·43	·48	·50	·50	·52	·65	·70
2 ,,	·38	·96	·94	·89	·77	·23	·40	·44	·49	·50	·46	·64	·68
3 ,,	·41	·96	·93	·86	..	·15	·38	·43	·47	·47	·42	·61	·62
4 ,,	·45	27·99	·91	·84	..	·08	·36	·40	·44	·44	·41	·60	·63
5 ,,	·48	28·02	·90	·82	..	28·03	·33	·37	·41	·41	·37	·59	·64
6 ,,	·50	·06	·92	·81	·65	27·98	·29	·36	·40	·38	·36	·59	·64
7 ,,	·53	·09	·93	·79	·68	·93	·26	·31	·36	·36	·35	·59	·64
8 ,,	·55	·12	·95	·78	·71	·90	·22	·30	·36	·35	·34	·59	·65
9 ,,	·56	·16	27·97	·79	..	·88	·19	·28	·34	·35	·34	·60	·65
10 ,,	·59	·18	28·00	·80	27·79	·86	·17	·28	·34	·35	·35	·61	·65
11 ,,	·61	·21	·03	·84	..	·90	·17	·29	·34	·34	·36	·62	·66
Midnt.	·65	·24	·08	·86	..	·94	·17	·29	·34	·35	·36	·63	·67
9th.													
1 a.m.	·66	·27	·13	·88	..	·96	·16	·29	·34	·34	·35	·63	·67
2 ,,	·68	·32	·14	·89	..	27·98	·17	·29	·34	·35	·35	·63	·67
3 ,,	·71	·37	·16	·91	..	28·00	·17	·28	·33	·33	·35	·63	·68
4 ,,	·75	·44	·19	·92	..	·03	·17	·28	·33	·31	·35	·63	·69
5 ,,	·79	·51	·23	27·95	..	·06	·21	·27	·31	·30	·38	·65	·70
6 ,,	·85	·56	·28	28·00	..	·10	·23	·27	·32	·32	·41	·68	·71
7 ,,	·89	·61	·31	·04	..	·13	·25	·27	·34	·33	·47	·71	·72
8 ,,	28·96	·68	·35	·10	28·30	·19	·28	·35	·38	·38	·50	·75	·70
9 ,,	29·00	·74	·38	·15	·32	·23	·31	·40	·44	·43	·58	·80	·78
10 ,,	·03	·78	·39	·19	·35	·26	·33	·46	·51	·49	·65	·86	·83
11 ,,	·08	·83	·41	·25	·38	·29	·34	·53	·56	·57	·70	·91	·88
Noon	·11	·86	·43	·28	·44	·37	·38	·56	·61	·59	·74	·95	·93
1 p.m.	·12	·88	·45	·31	·47	·42	·44	·62	·64	·65	·78	28·99	28·97
2 ,,	·14	·91	·47	·35	·51	·48	·50	·69	·70	·71	·83	29·04	29·01
3 ,,	·15	·94	·50	·39	·52	·53	·54	·74	·76	·77	·87	·08	·06
4 ,,	·17	·96	·53	·41	·55	·58	·61	·79	·83	·81	·91	·10	·08
5 ,,	·17	28·98	·57	·44	·57	·64	·66	·84	·87	·87	·93	·13	·09
6 ,,	·18	29·00	·60	·49	·60	·67	·69	·88	·92	·92	28·96	·17	·10
7 ,,	·18	·01	·64	·53	·63	·70	·74	·93	·96	·95	29·00	·18	·12
8 ,,	·17	·02	·67	·57	·66	·77	·78	·95	28·98	28·97	·01	·19	·15
9 ,,	·18	·03	·69	·59	·71	·76	·82	28·97	29·01	29·00	·04	·20	·17
10 ,,	29·22	29·04	28·71	28·63	28·75	28·78	28·85	29·01	29·04	29·03	29·05	29·22	29·18

TABLE IV.—VELOCITY OF THE WIND BY ANEMOGRAPHS.

Time.	Valencia.	Swanbister.	Aberdeen.	Glasgow.	Alnwick Castle.	North Shields.	Fleetwood.	Holyhead.	Yarmouth.	Berkhamsted.	Kew.	Falmouth.	Scilly.
Dec. 7th.													
10 p.m.	48	11	4	8	25	13	30	25	16	8	12	29	24
11 ,,	45	17	9	8	21	13	28	24	15	9	10	33	27
Midnt.	67	10	11	10	16	16	27	30	15	8	15	29	30
8th.													
1 a.m.	58	14	8	13	13	12	24	40	14	8	14	34	34
2 ,,	46	16	9	14	19	22	30	47	12	6	16	44	44
3 ,,	48	13	7	14	11	19	34	56	15	12	17	53	49
4 ,,	59	15	5	20	14	18	45	66	19	16	24	57	51
5 ,,	60	10	4	32	24	25	53	59	24	19	30	**61**	54
6 ,,	62	18	20	29	27	39	54	42	31	26	37	49	53
7 ,,	65	30	36	25	41	50	58	45	44	34	**42**	36	55
8 ,,	60	36	50	19	**44**	**51**	36	45	49	34	41	40	60
9 ,,	64	40	54	21	27	38	47	49	**64**	23	32	42	62
10 ,,	62	43	**59**	17	25	33	49	48	42	12	26	38	63
11 ,,	66	47	42	16	14	22	51	56	30	24	30	45	69
Noon	**72**	47	15	15	17	26	55	56	26	24	26	49	65
1 p.m.	70	51	6	11	18	30	46	67	22	23	33	45	67
2 ,,	69	53	6	16	23	25	60	**72**	20	27	33	49	66
3 ,,	67	56	5	16	21	24	72	68	27	26	27	49	**71**
4 ,,	57	56	5	17	26	42	74	56	27	23	33	54	64
5 ,,	63	**59**	4	23	32	35	66	52	21	23	33	50	66
6 ,,	52	58	4	20	27	32	62	51	24	24	27	50	68
7 ,,	55	57	5	18	20	31	56	48	28	27	39	51	63
8 ,,	53	56	12	13	24	35	64	45	29	28	41	50	63
9 ,,	53	56	8	18	17	26	63	43	34	30	38	43	65
10 ,,	47	53	10	16	10	23	58	44	35	35	37	47	59
11 ,,	44	49	10	13	2	23	52	39	39	27	39	44	58
Midnt.	47	32	14	11	10	19	49	38	35	28	34	40	60
9th.													
1 a.m.	43	35	13	11	17	18	52	40	35	28	35	40	59
2 ,,	41	22	17	8	16	16	46	36	37	25	37	39	58
3 ,,	36	21	19	15	23	27	41	47	35	27	37	40	58
4 ,,	29	19	20	11	31	30	36	54	34	26	38	41	53
5 ,,	25	16	19	15	26	25	38	60	35	23	39	39	61
6 ,,	28	14	18	20	26	25	41	70	28	26	37	41	61
7 ,,	28	14	17	16	25	21	50	66	21	26	33	38	54
8 ,,	27	17	17	19	25	22	71	64	18	29	27	35	41
9 ,,	24	24	21	18	25	18	**80**	62	18	26	23	33	40
10 ,,	29	21	19	28	32	26	65	58	20	25	19	36	40
11 ,,	30	21	21	33	39	35	74	55	20	33	23	33	37
Noon	20	17	24	**34**	33	34	76	58	27	30	19	38	37
1 p.m.	26	23	23	27	32	37	73	52	29	**38**	29	40	33
2 ,,	27	24	27	25	32	35	70	49	29	30	27	37	33
3 ,,	31	23	21	22	33	26	67	43	24	29	27	29	29
4 ,,	28	25	26	15	29	24	70	46	32	28	23	25	31
5 ,,	30	23	22	14	27	21	65	44	30	32	21	23	41
6 ,,	24	30	21	13	26	23	65	45	27	24	18	15	41
7 ,,	24	25	17	12	23	19	62	47	31	26	16	20	44
8 ,,	20	26	18	10	28	21	54	39	26	21	12	29	28
9 ,,	20	25	18	6	20	20	56	37	24	22	15	24	33
10 ,,	15	27	23	5	16	18	50	39	24	18	11	25	35

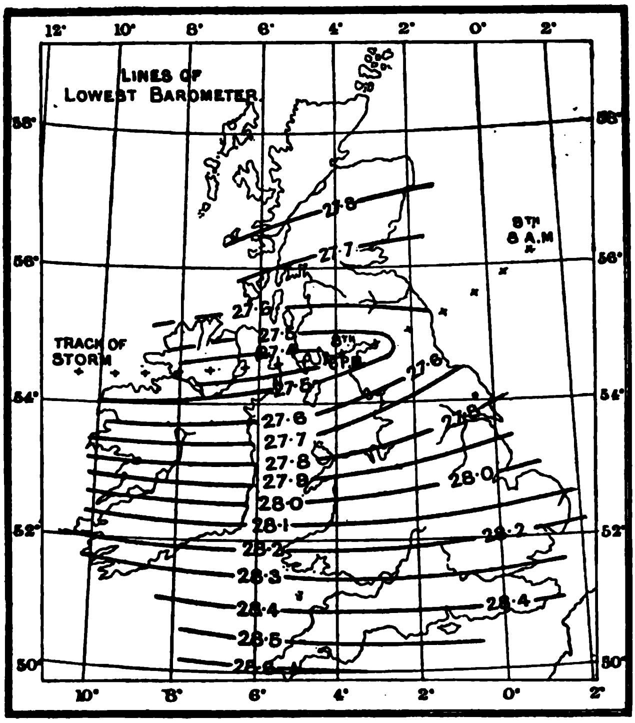
the 8th; the hail remaining in the streets unmelted for an hour or so, and presenting much the appearance of a fresh fall of snow.

The force of the gale was very severe over the whole of the British Islands. The highest velocity attained for the space of an hour was 80 miles at Fleetwood, whilst at Valencia and Holyhead the maximum hourly velocity was 72 miles, and at Scilly 71 miles. The duration of the gale was very prolonged in many parts. At Fleetwood the hourly velocity exceeded 30 miles for 65 hours, it exceeded 50 miles for 30 hours, and was upwards of 60 miles for 18 hours. The gale was, however, of very limited duration in the north, the hourly velocity at Aberdeen being above 30 miles, only from 7 to 11 a.m. on the 8th.

At Kew Observatory the maximum velocity in the hour was only 42 miles, but at Greenwich the pressure anemometer registered 23·5 lbs. on the square foot, at 4.30 a.m. on the 9th; this pressure, expressed as hourly velocity, is equivalent to 68 miles.

The feature which above all others probably renders this special storm of more than ordinary interest, is the very low level reached by the barometer. An immense amount of information has been collected on this head, much of which is reliable, and by the aid of which a chart (Fig. 5) has been drawn, showing the minimum barometer over the whole of the British Islands.

FIG. 5.



Some of the lowest readings on the 8th were as follows:—

	Ins.		Ins.
Belfast	1.30 p.m., 27·38	Newton Reigny	8 p.m., 27·57
The Mull of Galloway	2.30 p.m., 27·42	Whitehaven	5.30 p.m., 27·57
Armagh	0.30 p.m., 27·43	Cramlington	10.30 p.m., 27·59
Markree	10.30 a.m., 27·44	Durham	9 p.m., 27·61
Aghalee (Lurgan)	0.30 p.m., 27·44	Leith	7.30 p.m., 27·65
Loch Ryan	4 p.m., 27·44	Dublin	3 p.m., 27·76
The Mull of Cantyre	3 p.m., 27·52	Llandudno	6.30 p.m., 27·77
Cronkbourne, Isle of Man	8 p.m., 27·55		

The chart of lowest barometers shows that the mercury fell below 28 ins. over the whole of Scotland, and over nearly the whole of Ireland, except in the extreme south, also over the northern and central parts of England.

The area of absolutely lowest barometer readings was over the north of Ireland, and probably if trustworthy observations could be obtained it would be found that the barometer fell about 0·1 in. lower than the 27·38 ins. at Belfast.[1]

In drawing the chart care has been exercised to eliminate the doubtful observations which have arisen from very various causes, but principally from the absence of known errors for the barometers used; in some cases, however, the cisterns of the mercurial barometers were too small to allow the mercury to fall, and in others the verniers would not read sufficiently low, and in more than one instance it has happened that with the wheel barometers the pointer has outrun the 'bad weather' side of the dial, and has run over to "set fair," &c. Many amusing incidents might be given, but they would serve no good purpose further than conveying a certain amount of experience only obtainable at times of such exceptional phenomena.

The barometer did not sink to quite as low a level in this storm as in the "Great Storm of January 26th, 1884," which was discussed by Mr. Marriott and printed in the *Quarterly Journal*, Vol. X. p. 114, when the lowest reading was 27·332 ins. at Ochtertyre, near Crieff, which is 0·05 lower than any authentic reading in the December gale. The barometer, however, fell lower in the gale of December 8th and 9th in Ireland, and in the northern and central parts of England, than has been previously observed. The two disturbances of January 26th, 1884, and December 8th and 9th, 1886, were very similar in many ways, but the track of the centre in the January 1884 gale was further to the north.

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[1] At Omagh in Tyrone a reading of 27·24 ins., reduced to sea level, was recorded at 1 p.m. on the 8th, and undoubtedly the position of that station was in the direct track of the centre, and at the time when the depression was at its deepest. Mr. Scott has had the barometer compared with a standard, but the instrument is a wheel barometer and graduated only to 28·0 ins. Although the comparison subsequently made with the standard shows the readings to be fair, on comparing the readings on other days, when the weather was quieter, with the observations in the *Daily Weather Reports*, the differences are so erratic, ranging over 0·5 in., that I have not considered it satisfactory to quote the reading as trustworthy.

In London the lowest barometer was 28·30 ins., and there have been but three lower readings in the neighbourhood of London during the present century, these were:—

		Ins.
1814.	January 29th	28·23.
1821.	December 25th	28·02.
1843.	January 13th	28·27.

In the gale of January 26th, 1884, the lowest barometer in London was 28·52 ins.

At Stonyhurst Observatory, where the barometer fell to 27·77 ins., the reading was 0·4 in. lower than at any time in the last 40 years, the lowest previous reading being 28·19 ins., on December 6th, 1847.

Among other previous low readings in the British Islands are:—

		Ins.
1839.	January 7th ...	27·69, at Aberdeen.
1852.	December 27th	27·98, at Culloden.
1865.	December 31st	27·63, at the Hoy Low Light, Orkney.

There is also the reading of 27·33 ins. which was observed by a Standard barometer belonging to the Meteorological Office on board the R.M.S. *Tarifa*, on February 5th, 1870, in about the same latitude as London, but 500 miles to the west of our Islands.

Mr. Blanford, in a communication to *Nature*, Vol. 35, p. 344, dated January 6th, 1887, referring to the reading of 27·332 ins. (reduced to sea-level) at Ochtertyre, which was quoted as the lowest reading observed by man anywhere on the land surface of the globe, states that "the cyclone which on the morning of September 22nd, 1885, swept over False Point, on the coast of Orissa, gave the lower readings 27·135 ins. at the beginning of the central calm, and 27·154 ins. half an hour later (both readings reduced to 32° and sea-level)." The readings are shown by Mr. Blanford to be thoroughly authentic, and were made by a verified Standard barometer. For comparison with English Standards a further subtractive correction of ·011 in. has to be applied, which would make the lowest reading 27·124 ins.

Lower readings than this have been noticed; for instance, 26·30 ins. was recorded on board the ship *Duke of York*, on the coast of Kedgeree, in 1833, and quoted by Col. Reid, but at this date ship barometers were of a very questionable character.

In Professor Loomis's *Contributions to Meteorology*, Chapter II., a reading of 31·72 ins., reduced to sea-level, is given at Semipatalinsk on December 16th, 1877, the reading at Barnaul being 31·63 at the same time, which gives a difference from Mr. Blanford's reading, 27·12 ins., of 4·6 ins.; this is probably the maximum range of the barometer ever observed at the earth's surface.

The gale was supposed to have been foretold on December 3rd by the *New York Herald*, in the following warning:—

> "A large anticyclone, barometer maximum 30·90 ins., is now moving from the Lakes towards Nova Scotia, and will probably cause Westerly gales south of the 'lane' for west bound steamers; preceded by a depression which may disturb the weather west and north of the British coasts between December 7th and 8th."

An examination has been made of several ships' logs, among others those lent by the Cunard Steamship Company, but the Atlantic was in such a disturbed condition at this time that it is not possible to track the passage of the storm across the Atlantic with any certainty. The U.S. Signal Service Charts, however, show that a disturbance was passing over Newfoundland on the 4th and travelling eastward, and this had in its rear an area of very high barometer readings. Doubtless this is the explanation of the message received from the *New York Herald*, but a study of the *North Atlantic Synchronous Charts*, now being published by the Meteorological Office, makes one shrink from attempting to track a certain storm without a fairly large number of observations.

The storm will long be remembered in connection with the capsizing of the Southport and St. Anne's life-boats near Formby, resulting in the loss of 27 lives out of 29, which constituted the two crews. The scene of the disaster was not far from Fleetwood, where, as is shown by the anemometrical results, the worst of the gale was experienced.

The following statement of the destruction to shipping has been supplied by the Secretary of Lloyd's :—

GALE OF DECEMBER 8TH AND 9TH, 1886.

NUMBER OF VESSELS TO WHICH CASUALTIES OCCURRED DURING THE GALE OF THE 8TH AND 9TH DECEMBER, 1886, ON THE BRITISH COASTS, AS REPORTED IN LLOYD'S LISTS.

Nature of Casualty.	Sailing.	Steam.	Total.
Abandoned	3	..	3
Foundered[1]	23	..	23
Stranded	81	8	89
Dismasted	5	..	5
Other causes of damage	73	24	97
Total	185	32	217

[1] There were doubtless other vessels foundered during the gale, the names of which are not yet known, as application to the Committee has not yet been made to post them as missing.

In conclusion I have to thank Mr. Scott and the Meteorological Council for allowing me free use of the information in the Meteorological Office, also Mr. Symons for handing over to me all the material relative to the storm which has come into his hands, and Mr. Buchan for valuable information from the Scottish stations; among others I would also thank Mr. Marriott for the assistance he has afforded in the drawing of the large diagrams.

DISCUSSION.

Mr. **GASTER** said this was a most extraordinary storm in regard to its depth, the steepness of the gradients, and the time of its duration, but in other respects it did not differ materially from ordinary barometric depressions which pass over our northern districts from the westward. Such depressions frequently advance with the utmost rapidity until they touch our coasts, when their speed slackens considerably, their movements become erratic, and the systems fill up. In the case of the storm of December 8th and 9th, an examination of the *Daily Weather Charts* showed that it approached very quickly, but moved slowly across Great Britain and the North Sea, gradually filling up as it progressed, and finally disappearing over the western part of Norway. The Meteorological Office warnings of this storm were issued in good time, and when it struck our coasts the signals announcing its approach were all flying. He very much wished that some able investigator could find time to consider the various types of storms which visit us from time to time. To him these instances which have been worked up so completely by Mr. Harding and others would be invaluable, and would help us to arrive at some good ideas as to their origin and the laws which determine their path. He (Mr. Gaster) did not believe that this storm came to us from America, although there was no doubt that some of our storms could be traced as coming from that country. The map of absolute lowest pressures observed in this storm was both unique and interesting.

Dr. MARCET inquired what was the force of the wind at Fleetwood at the time of the capsizing of the Southport and St. Anne's lifeboats.

CAPT. TOYNBEE said that the occurrence of thunderstorms in the South-eastern quarter of the depression was characteristic of these severe storms, and was probably caused by a meeting between the ascending South-westerly and descending North-westerly currents of air. He thought that the Atlantic Synchronous Charts which are being prepared by the Meteorological Office, of which two parts are now in the Society's Library, will enable Meteorologists to form a better opinion on the question as to whether such gales can be forecasted by telegram from America. Mr. C. Harding has had considerable practice in the working up of Atlantic data, and was consequently able to collate and discuss data relating to such storms quickly and in a very complete manner.

Mr. ABERCROMBY said Mr. Harding certainly deserved praise for the excellence of the work contained in his Paper, and for the rapidity with which the information collected had been put together. It was not easy to interpret the meaning of the chart of lines of equal barometric minima which Mr. Harding had constructed, although it certainly showed that after reaching the coast of Lancashire the depression began to fill up. If a uniform cyclone traversed the country on a uniform path, the lines of equal barometric depression would be represented by a series of straight lines parallel to the line of the central path. In Mr. Harding's chart there was a long oval-closed isobar stretching from the north of Ireland into Lancashire. This, and the slight convergence of the isobars, would be the product of the passage of a depression which began to fill up after it had crossed St. George's Channel. He wished to ask whether in this cyclone the centre of wind rotation was coincident with the centre of barometric depression. It had often been asserted that these two centres did not always cover the same spot; but he was not satisfied with the existing evidence.

Mr. ARCHIBALD inquired whether Mr. Harding had ever plotted barometer and wind observations for a certain level, say 500 feet or more above the surface of the earth. He thought it would be extremely interesting if something of this kind were done, as we should then be able to see in what respects the circulation of the wind at a higher level differed from the wind circulation at the surface of the earth. Regarding Mr. Harding's map of isobars of absolute minima, he said it really represented the form of the deepest section of the storm at right-angles to its direction of motion at the time of its passage over the places included within the isobars.

Mr. STANLEY said that possibly the rapid rate at which depressions travelled across the Atlantic was owing to the comparatively level sea surface presenting no obstacles to impede their progress, their rapid rate of progress being retarded on reaching land, and there forming by resistance eddies or cyclones, usual in all forms of fluid resistance.

Mr. ARCHIBALD inquired whether the barometer reading given by Mr. Blanford, and quoted by Mr. Harding, was corrected for gravity.

Mr. SCOTT said with reference to Dr. Marcet's question that the exact time of the capsizing of the lifeboats was not known, so the velocity of the wind at the time of the disaster could not be stated. He drew attention to the enormous changes of temperature during the week previous to the storm on two distinct occasions (viz. December 4th and 6th), exceeding 20° in twenty-four hours at more than one station, showing that the atmosphere was in a state of very disturbed equilibrium.

Mr. C. HARDING, in reply, said he believed this storm did not cross the Atlantic. The synchronous work which was now being done in the Meteorological Office, the results of which he believed would prove very valuable, showed how rapidly secondaries developed and moved round the southern portions of a primary disturbance. It was these secondaries which formed the great difficulty of English weather forecasting. The map of barometric minima simply gave the lines of equal absolute minimum pressure without any regard to time ; but the time of the occurrence of the minimum readings was shown on the original diagram by small figures below the barometer readings ; these, however, have not been reproduced in the published diagrams, owing to the smallness of the scale. Regarding the force of the wind at the time of the lifeboat disaster, the anemometer at Fleetwood registered very high velocities through the storm, and from the table given in the Paper it would be seen that this part of the country experienced the greatest violence of the storm. He thought that hardly sufficient observations could be obtained to carry out Mr. Archibald's suggestion. He believed that the reading quoted from Mr. Blanford was corrected for gravity at the latitude of Calcutta.

REPORT

OF THE

WIND FORCE COMMITTEE.

DRAWN UP BY

G. CHATTERTON, M.A., M.Inst.C.E., F.R.Met.Soc.

Plate IV.

[Read April 20th, 1887.]

The Committee in presenting this preliminary Report regret that they have not yet been able to complete the important investigation that has been referred to them by the Council.

In this Report the Committee have dealt mainly with that portion of the investigation relating to Beaufort's Scale of Wind Force and the equivalent Velocity in miles per hour.

The Committee have compared the velocities as recorded by the anemographs at Holyhead, at Falmouth and at Yarmouth, with the entries of Beaufort's Scale in the logs of the neighbouring Light-vessels and Lighthouses for the year 1881, and they give the results obtained in the accompanying table (p. 216).

Result No. I. was obtained by comparing Beaufort's Scale as recorded every three hours, commencing at midnight, at the South Stack Lighthouse with the records of the Holyhead Anemograph for Westerly winds.

Result No. II. was obtained by comparing Beaufort's Scale as recorded on board the Carnarvon Bay Lightship with the Holyhead Anemograph for Westerly winds.

Result No. III. was obtained by combining results Nos. I. and II., and rejecting all observations where the direction of the wind at the South Stack Lighthouse differed by more than 8 points from the direction at Carnarvon Bay Lightship.

TABLE OF VELOCITIES (IN MILES PER HOUR) CORRESPONDING TO BEAUFORT'S SCALE FOR THE YEAR 1881.

Result.	Position of Anemograph.	Names of the Lightships or Lighthouses.	Direction of Winds.	Force = 0.		Force = 1.		Force = 2.		Force = 3.	
				Veloc.	No. of Obs.	Veloc.	No. of Obs.	Veloc.	No. of Obs.	Veloc.	No. of Obs.
I.	Holyhead	South Stack Lighthouse	Westerly	4·8	49	6·7	102	9·9	225	13·9	292
II.	,,	Carnarvon Bay Lightship	,,	4·6	49	6·0	54	8·0	127	11·6	212
III.	,,	South Stack and Carnarvon Bay	,,	4·7	98	6·5	156	9·2	352	12·9	504
IV.	,,	Carnarvon Bay	Easterly	5·5	29	7·0	46	7·6	108	11·7	228
V.	,,	Carnavon Bay	Easterly and Westerly	4·9	78	6·5	100	7·8	235	11·6	440
VI.	Falmouth	Eddystone Lighthouse	Southerly	6·6	33	6·9	90	10·0	122	12·8	270
VII.	,,	Wolf Rock Lighthouse	,,	7·2	25	6·3	61	9·1	95	11·8	216
VIII.	,,	Eddystone and Wolf Rock	,,	6·8	58	6·7	151	9·6	217	12·4	486
IX.	Yarmouth	Leman & Ower, Newarp, Cockle, Nicholas Gat Corton, and Galloper	Easterly	..	..	..	..	9·1	160	15·1	281
X.	,,	Newarp, Cockle, Nicholas Gat and Corton	,,	..	..	5·9	108	10·1	224	17·1	308

Result.	Force = 4.		Force = 5.		Force = 6.		Force = 7.		Force = 8.		Force = 9.		Force = 10.		Force = 11.		Force = 12.	
	Veloc.	No. of Obs.	Veloc.	No. of Obs.	Veloc.	No. of Obs.	Veloc.	No. of Obs.	Veloc.	No. of Obs.	Veloc.	No. of Obs.	Veloc.	No. of Obs.	Veloc.	No. of Obs.	Veloc.	No. of Obs.
I.	19·0	256	23·3	256	27·6	256	33·2	188	39·8	83	43·7	22	52·5	14	60·2	5	..	..
II.	17·2	407	22·9	332	27·5	256	34·4	162	38·8	73	45·3	23	52·5	11	58·8	6	..	..
III.	17·9	663	23·1	588	27·5	512	33·7	350	39·3	156	44·5	45	52·5	25	59·4	11	..	..
IV.	16·6	324	22·9	257	29·4	176	37·0	111	45·2	58	47·7	9	51·2	6.	..	..	..	..
V.	17·0	731	22·9	589	28·3	432	35·4	273	41·6	131	46·0	32	52·1	17	..	..	..	..
VI.	17·6	236	21·5	196	26·0	125	29·7	72	36·5	63	40·8	25	40·8	7	43·3	6	46·0	2
VII.	16·0	286	20·0	212	25·5	169	29·4	100	37·8	63	41·3	18	47·0	1	..	..	..	..
VIII.	16·7	522	20·7	408	25·7	294	29·5	172	37·2	126	41·0	43	41·6	8	..	..	..	..
IX.	24·3	281	33·1	166	42·4	97	51·4	33	57·9	5	66·6	1	..	..	..	..	..	..
X.	25·8	251	34·6	160	41·5	88	49·2	32	54·3	5	66·7	2	83·0	1	..	..	..	..

Result No. IV. was obtained in a similar manner to result No. II., except that Easterly winds only were considered.

Result No. V. was obtained by combining results Nos. II. and IV.

Result No. VI. was obtained by comparing Beaufort's Scale as recorded every three hours at the Eddystone Lighthouse with the records of the Falmouth Anemograph for Southerly winds.

Result No. VII. was obtained in a similar manner to No. VI., by comparing Beaufort's Scale, as recorded at the Wolf Rock Lighthouse, with the Falmouth Anemograph for Southerly winds.

Result No. VIII. was obtained by combining results Nos. VI. and VII.

Result No. IX. was obtained by comparing Beaufort's Scale as recorded on the Lightships *Leman* and *Ower*, *Newarp*, *Cockle*, *Nicholas Gat*, *Corton* and *Galloper*, every three hours, with the Yarmouth Anemograph for Easterly winds.

Result No. X. was obtained in a similar manner to Result No. IX. by omitting the observations taken on the *Leman* and *Ower* and the *Galloper* lightships, which may possibly be considered to be too distant from the Yarmouth Anemograph for fair comparison.

In results Nos. IX. and X. if the direction of the wind as recorded on any two of the lightships differed by more than 8 points the mean observation for that period was rejected.

After a careful consideration of the whole of the results of this investigation the Committee are of opinion that the velocities shown by the Yarmouth Anemograph corresponding to Beaufort's Scale, as recorded on board the lightships, are too high, and that the velocities shown by the Falmouth Anemograph are probably too low. The Committee, however, have not yet had before them sufficient data to determine, with any degree of certainty, the relation between Beaufort's Scale of Wind Force and the equivalent Velocity in miles per hour. Neither are they able to recommend any existing scale that should be adopted or modified.

The results contained in the Table are also given in a diagram, from which it is seen that there is a remarkable agreement between the light-vessels or lighthouses in the same district, which, in the opinion of the Committee, points rather to the element of doubt being attributable to the anemometrical records and not to the estimation of force by Beaufort's Scale. It is assumed that, as the anemographs are of the same pattern and similarly geared, the registrations by the different instruments under similar conditions would be in fair agreement with each other. There are, however, difficulties in the way of exposure which doubtless introduce anomalies not easily accounted for. At Falmouth, for instance, although the anemometer is placed on fairly high ground, which rises in part very sharply, the Southerly winds to which the anemograph is principally open, and which blow from off the sea, pass over a part of the town and probably undergo considerable modification, being thrown into all sorts of eddies and being thoroughly broken up before reaching the anemograph. The effect of this would probably be to lessen the velocity shown by the anemograph, and this conclusion is confirmed by the results obtained.

At Yarmouth winds from the Eastward only have been used, and in this case the anemograph is placed some 10 feet above the roof of a fairly large house directly fronting the sea, and which would receive unchecked the full force of the Easterly winds. The Committee are rather of opinion that this exposure may place the anemograph in an accelerated wind current, and certainly the high velocities obtained by the comparisons made at this station fully bear out this supposition. As the Westerly winds pass over the whole town before reaching the anemograph they have not been used in the discussion, although the tabulations have been made; the observations show a much smaller velocity than the Easterly winds for the same unit of Beaufort's Scale.

At Holyhead the exposure of the anemograph is satisfactory, and the results obtained by comparing the Easterly with the Westerly winds are very similar. Result No. V., which is a combination of Easterly and Westerly winds as observed on the Carnarvon Bay Lightship, gives a regular, and probably the most reliable, curve of all.

The Committee have given great consideration to the question of running an anemometer on a locomotive engine, so as to investigate the value of the coefficient for Robinson's cups. But the practical difficulties that have presented themselves in the way of procuring the use of a locomotive on a particular day and at a suitable place, and the difficulty of exposing the anemometer so as to be free from currents caused by the motion of the locomotive, have induced the Committee to abandon the idea of this experiment, the cost of which would be considerable.

The Committee, however, hope that they will shortly be able to carry out some experiments by running a small anemometer on a "whirl-about."

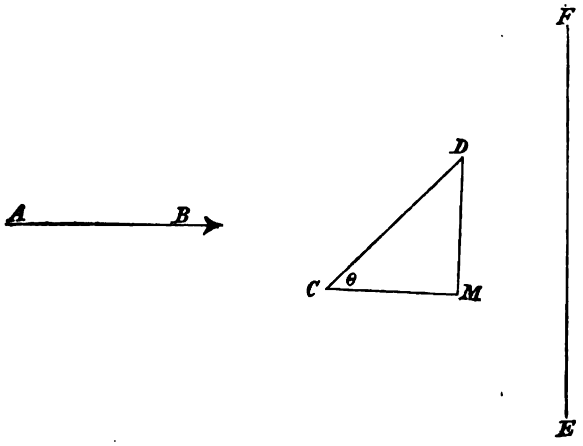
A NEW FORM OF
VELOCITY ANEMOMETER.

By W. H. Dines, B.A., F.R.Met.Soc.

[Read April 20th, 1887.]

In this instrument an attempt has been made to measure the velocity of the wind by the rotation of a small pair of windmill sails, the pitch of the sails being altered automatically, so that their rate may always bear the same ratio to that of the wind.

The principle by which this is accomplished may be explained as follows:—Let A B represent the direction of the wind, C D a thin strip of metal, lying in a plane perpendicular to the plane of the paper, and suppose that E F is a wire on which any light substance, *i.e.* a feather, is capable of sliding.



Draw C M parallel to A B, and D M parallel to F E, that is at right angles to A B or C M, and let the angle D C M $=\theta$.

First suppose that C D is fixed, then the wind on meeting C D will be deflected, and will move the feather along the wire towards F; now let the strip of metal C D be moved rapidly across the direction of the wind, in the direction F E, it will obviously tend to draw the feather after it towards E, and the strength of this tendency will depend on three things, viz. the velocity of the wind, the velocity of C D, and the angle θ. Suppose u to be the velocity of the wind, and v the velocity of C D. Now if $v=o$ the feather is moved towards F, and if v be very great it is moved towards E, there must therefore be some value of v for which the feather is not affected. This will be the case if $v=u \tan \theta$. When this condition is satisfied the particles of air move in straight lines, and no deflection is caused by the moving surface C D, assuming of course that its thickness is inappreciable, and that the friction between it and the wind is of no consequence. Considering the very small resistance experienced by a thin plate presented with its edge to the wind, both these assumptions seem allowable.

Now the only condition about the direction of the motion of C D is that it shall be perpendicular to the wind; suppose therefore that the strip of metal C D is rigidly connected with a rod pointing in the direction of the wind, and revolving with uniform angular velocity, and also suppose that the wire E F is bent into a circle with its centre on this rod. Then the linear velocity of C D will depend on its distance from the rod or axis of rotation, and if this distance be arranged so that $v=u \tan \theta$, the feather will not be moved; also since the angle θ may be altered at pleasure, the strip C D may be placed at any distance from the axis, so long as that distance is made proportional to $\tan \theta$. Hence we may build up a continuous surface out of a large number of strips of which C D may be taken as a type, and such a surface may be rotated about its axis in a current of air (the axis of course pointing in the direction of the current) without causing any deflexion or whirl in the air passing over it; and to find the velocity of rotation necessary for this result, we have only to make that part of the surface for which $\tan \theta=1$ move with the same velocity as the current. If this velocity be too great, the feather, which for the sake of illustration we have supposed placed on a circular wire behind the surface, will be drawn round in one direction; but if too slow, it will be driven round in the opposite direction.

Such a surface is called a helicoid, and were it possible to make it and the clockwork train necessary for recording its revolutions move without friction, it would form a perfect meter for the velocity of any fluid. I believe that an instrument of the kind might in many cases be used with advantage, but have not at present had time to make any experiments on the subject.

The mechanical details of the instrument may be seen in the patent specification by any one interested in the subject, they are comparatively simple.

Briefly, a helicoid is fixed at the front, and a small pair of sails of variable pitch at the back of a steel rod, and just behind the helicoid a light fan, which can turn on the same axis, but is independent of the helicoid and sails. If the rotation be too rapid, the fan turns in the same direction as the helicoid, and by its motion alters the pitch of the sails so that their motion is retarded; if, on the other hand, the friction is increased, or from any other cause the motion becomes too slow, the fan is turned in the other direction, and the rate is increased. The motion is communicated to a vertical rod, which passes down the hollow pivot on which the instrument turns; it is kept facing the wind by a vane. It is convenient to connect the vertical shaft to the recording dial by a light flexible wire, all that is necessary being to place the dial approximately beneath the anemometer; by this means the trouble of ascending a high tower or ladder is avoided, except when oil is required.

The advantages of this instrument seem to me to be :—

(1.) That no constant has to be experimentally determined.

(2.) That the readings for all winds except those of low velocity are independent of the friction.

(3.) That instruments of different sizes read alike.

(4.) That, being light, it may be placed on a high pole, with the dial at the bottom, and need only be taken down for oiling.

On the other hand it is a disadvantage that a vane or other contrivance is required to keep it facing the wind, also that considerable effect is produced on the readings if the metal of either the helicoid or fan is accidentally bent or dented.

As no theoretical reason can be given why the instrument should read too high rather than too low, or *vice versâ*, I felt convinced, even before testing, that the mean of a large number of experiments would give about the true value, but I was uncertain whether it would be possible to make the fan turn sufficiently free from friction to make the instrument reliable. In practice, however, the jar produced by the motion of the other parts overcomes this friction, and, however the pitch of the sails be set at first, it is very soon automatically brought to the proper amount.

A whirling machine of 42 feet diameter, erected in the open air, has been used to test these anemometers, and by its aid two instruments have been run over a combined distance of 273 miles at rates ranging from 4 to 47 miles an hour.

As, however, it is impossible to obtain a sufficient number of perfectly calm days to carry on the experiments, it is necessary to consider the correction which must be applied on account of the natural wind. This is purely a mathematical question, and presents no special difficulty; if v be the velocity which is given to the instrument, and u the velocity of the wind, the mean recorded velocity should be $\int_0^{2\pi} \sqrt{(u^2 + v^2 - 2\,u\,v \cos\theta)}\, d\theta,$ and the value of this integral can be obtained in a series of powers of $\frac{u}{v}$ to any required degree of approximation. I had worked out the formula as far as $\left(\frac{u}{v}\right)^7$ before seeing Professor Stokes's paper on the Crystal Palace experiments, in which he states that it is unnecessary to go beyond the second term of the series (the odd powers vanish), and also that the corrections in general are so small and unimportant that the necessity for them offers no real objection to this method of testing. Professor Stokes's opinion on this point is of course conclusive, but I think his remarks do not refer to velocities of much under 10 miles an hour. I have, however, been fortunate in finding one or two days on which it was impossible to say from what direction the wind was blowing, and all experiments relating to low velocities have been made on these days.

The corrections, when necessary, have been made by subtracting $\frac{1}{4}\frac{u^2}{v}$ from the velocity recorded by the instrument. This gives the result correct to the second decimal place when v is greater than $5u$, and to the first decimal place when v is greater than $2u$. Owing to the difficulty of getting a perfectly correct estimate of the velocity of the wind, and also to the fact that a gusty wind would not have the same effect as a steady wind of the same mean velocity, it is not advisable in my judgment to rely upon experiments in which a correction of much more than 2 per cent. is necessary. I have, however, found no difficulty in getting a large number of reliable experiments, and, after a practical trial, agree with Professor Stokes that these corrections offer no objection to the method, unless perhaps in the case of velocities under 4 or 5 miles an hour.

It is necessary to alter the vane so that it may form an arc of the circle in which the instrument is moving, but in a circle of 42 ft. diameter the alteration required is small; the alternative is to fix the instrument on its pivot in the proper position, but this is inadmissible when a correction is required for the natural wind. The question has been raised whether any eddy is left which might affect an instrument tested in this manner. The plan I have adopted to throw light on this point has been to burn some wet straw or similar material and make the anemometer pass through the smoke; so far as I can judge the eddy has always died away some time before the instrument has returned to the same spot.

The strain produced by the centrifugal force is exceedingly troublesome, in fact both instruments have been slightly damaged from this cause. At a rate of 30 miles an hour in a circle of 42 ft. diameter this force is equal to nearly three times the weight, it varies directly as the square of the velocity and inversely as the diameter of the circle. In the case of a Robinson's anemometer, as has been pointed out by Prof. Stokes, one effect must be to increase the pressure on the bearings and therefore also the friction, thus rendering the constant determined by this method too high.

Two instruments have been tested, the one being just double the other in size; the plan adopted was as follows. The instrument was placed on the whirling machine and the indication of the dial noted down; it was then moved through a given distance, generally 5, but sometimes 2 or 3 miles, the distance being known from the registered number of turns of the machine, 40 turns being equal to 1 mile; the dial was then again read, and the time occupied in the experiment noted; the difference of the readings gives the distance registered by the instrument, and the mean velocity is obtained from the known distance and the time. The correction for natural wind, if any, was then applied, and the known distance traversed compared with the corrected distance registered by the instrument, the percentage error for the particular experiment being thus obtained. The dial used gave the reading in miles, to the fourth decimal place.

The velocity of the wind was obtained by an instrument similar to those tested, but when very light it was estimated by the deflexion of a light thread, the deflexion of the thread being compared with that produced when the same thread was slowly moved in still air with a known velocity.

In many experiments an electric bell was used, the contact being made every tenth of a mile; this has been found a useful check on the readings, and has shown very clearly the effect of the natural wind on the experiments, any increase of strength being at once shown by the greater rapidity of the contacts; it was, however, primarily attached for another purpose.

Both instruments would begin to turn with a velocity of about 2 miles an hour; but when the friction has been artificially increased, the increase has been such that a velocity of 10 — 15 miles has been required to start them.

The results are given in the following table:—

	No. of Experiments.	Actual Distance run.	Registered Distance.	Highest percentage.	Rate.	Lowest percentage.	Rate.	Mean Error.
Large Instrument	26	99	99·79	105·27	18	96·29	25	2·28
Do. with friction	7	24	24·19	108·90	21	94·92	20	3·10
Small Instrument	21	103	99·88	103·66	36	90·10	45	4·15
Do. with friction	8	37	35·12	101·20	25	90·01	42	5·19

In this Table the result of every experiment has been included, except one made with the larger instrument; this gave a percentage of 88 only, and standing so entirely alone it has been rejected as being most likely due to a mistake in reading the dial. The smaller of the two anemometers has given the lowest readings, but this is not due to its size, but to some slight departure from the proper shape of either the helicoid or fan; in fact, I consider the greatest defect of the instruments to be the ease with which the readings are altered by bending either of these parts. In both the variations from the mean were less in those experiments made before the high velocities were used, the perfect balance of the fans having been destroyed by the strain caused by the centrifugal force; but, apart from the question of testing by this method, I have found by experience that greater strength is required to enable them to stand a severe gale; no doubt, however, sufficient strength can be given without impairing the sensitiveness.

In conclusion I must state that I consider the velocities which are at present commonly reported to be too high; and I have, I think, good ground for this opinion. I have lived near a high railway embankment, and some years back have ridden many miles on a locomotive, but, although constantly looking for it, I have never seen the smoke driven in front of a train, not even a goods train, except when leaving a station. A train no doubt causes a great disturbance in the air, and on a calm day carries the steam along with it, but if the wind be blowing with a greater velocity from a point nearly behind it, it must inevitably drive the smoke in front. Now as the exposure on an embankment is fairly good, and the steam generally rises a little before being lost sight of, it seems clear that velocities greater than the average pace of the slower trains, which cannot be much over 25 — 30 miles, are very uncommon at the inland stations.

It seems to me that we cannot feel much confidence in velocities recorded by an anemometer for which it has not been directly tested. In Robinson's the constant is different for different velocities, but how can we be certain what it should be for those rates at which it has not been experimentally determined? The plan of finding a complicated formula to suit the known values and then assuming that it also suits the unknown does not seem satisfactory.

There is, however, another equally important question connected with this subject, and until that is settled a perfect anemometer, if we could get one, would be of little value; of course I mean the exposure. The top of a building seems to be about the worst possible position, for we well know the way in which the air rushes round the corner of a street or isolated building on a windy day, and the same effect must occur more or less, for my own part I think more, at the top. A uniform height will not meet the difficulty, for a height of 50 ft. would mean quite a different exposure in an open situation to what it would in London, or near the edge of a wood. I think that we require more knowledge on the effect of elevation upon the velocities, and also of the position with regard to trees and buildings, before the question an be definitely settled.

DESCRIPTION OF TWO NEW MAXIMUM PRESSURE REGISTERING ANEMOMETERS.

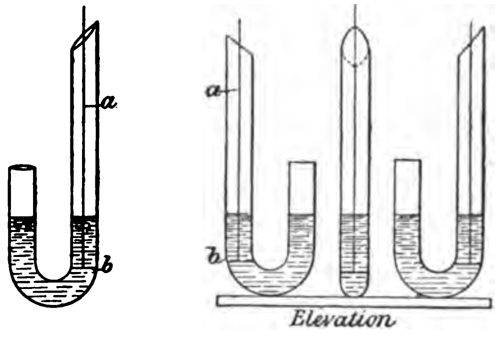
By G. M. WHIPPLE, B.Sc., F.R.A.S., F.R.Met.Soc.

[Read April 20th, 1887.]

The instrument represented in figs. 1 and 2, and of which models are exhibited to the Meeting, is designed with the view of placing simple instruments in the hands of observers to enable them to record the maximum wind pressure which has occurred during any interval of time. The simplest instrument is a modification of the Lind's, Hagemann's, or Pitot's water-pressure Anemometers, provided with an apparatus for registering the maximum height the water attained during the period which elapsed since the last setting of the instrument. The principle adopted for obtaining the maximum effect of the wind force is the well-known one, that the wind rushing past an obstacle produces a partial vacuum in its rear; and hence if a pressure-gauge is placed behind such a plate the exhaustion will cause an elevation of the fluid in the limb immediately in contact with the back of the plate. By cutting off the gauge tube obliquely at an angle of about 60°, the tube itself is made to form the plate, and it is found by experiment that the amount of air drawn through such a tube is more than that drawn through a vertical tube cut off at right angles to its axis.

I accordingly take 4 or 8 inverted glass siphons, the long limbs of which are provided with obliquely cut mouths, whilst the shorter are square. (Fig. 1.)

Fig. 1.



The inverted siphons are placed vertically and radially in a circle, with the long limbs outwards. (Fig. 2.) In the inside of each long leg is placed a thin zinc bar soldered to a perforated piston or plug, suspended just above the bottom;[1] water being poured into the tube, the arrangement forms an ordinary

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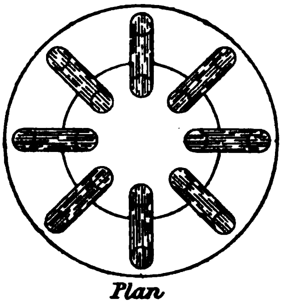
[1] The object of the perforated disc is to diminish pumping of the water in the tube.

FIG. 2.

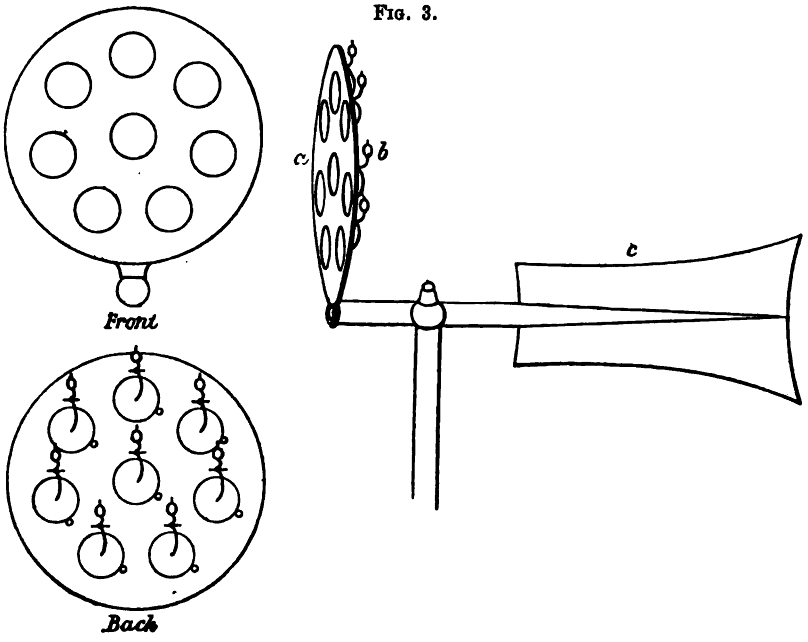


pressure-gauge. If now it is exposed to the wind, the effect of the air current over the inclined lip will be to raise the level of the water in that branch of the siphon above that in the other, and if bichloride of platinum be dissolved in the water, by its action the height to which it rises will be recorded by a blackening of the zinc bar. This height being measured by withdrawing the bar and placing it against a scale will give an indication of the maximum effect of the wind during the interval, and comparing the indications of the various radially placed tubes the direction from which the gust blew will be found.

Sufficient experiments have not yet been made to permit of a definite scale of wind pressure or velocity being computed. The suggestion as to the employment of a platinum solution for the gauging rod is due to a remark by Prof. Unwin in the *Proc. Inst. C.E.*, Vol. LXIX. Part III. page 105.

The second form of registering maximum pressure anemometer is derived from the ordinary pressure plate instrument; a circular metallic disc (*a*) of 9⅝ ins. diameter exposing a surface of half a square foot is kept at right angles to the wind by means of a suitable vane (*c*) (Fig. 3). This disc is perforated

FIG. 3.



by 8 circular apertures each of $1\frac{3}{8}$ inch in diameter, that is to say, each exposing a surface $\frac{1}{100}$ of a square foot. Behind each aperture a disc $1\frac{3}{4}$ inch in diameter is loosely held *in situ* by means of a bent lever loaded with a weight (*b*). These weights are arranged so as to press upon the different discs with pressures proportionate to the values usually assigned to wind-pressures as measured by the various degrees on the Beaufort scale. Each little disc is attached to the large disc by means of a link, so that when driven from contact with it by the action of the wind overcoming the back pressure of the weighted lever it falls down, and leaving the hole it covered open, indicates the maximum wind force which has displaced it.

The movable discs and apertures over the surface of the fixed disc are arranged in accordance with the results afforded by Messrs. Curtis and Burton's[1] experiments, so that they shall experience the full force of the wind pressure, and not be subjected to the diminished pressure exerted on the margins of a circular pressure plate. As regards the negative or back pressure on the plates, I have not proposed to take it into consideration, as I find in the discussion on the paper read before the Inst. C. E. referred to[2] above, opinion was much divided as to the possibility of its existence or not, and it is not considered in some of the chief pressure-plate anemometers now at work. If, however, experiments should render it necessary to allow for it, a slight readjustment of the weights will be all that is required. Rigid attachment of the apparatus to a firm support is imperatively necessary, to avoid the discs being shaken down by mere vibration.

DISCUSSION.

The President (Mr. Ellis) said :—Of the three papers before us to-night on the subject of wind measurement it will be seen that the Report of the Wind Force Committee consists principally of a comparison of wind force as estimated by Beaufort's scale at different Lightships with the velocities measured at adjacent anemographs. There is, to a certain extent, agreement in the results, with also some discordance, and on the whole the Committee felt unable to determine with any certainty the velocities corresponding to the numbers of Beaufort's scale, neither were they able to recommend any existing scale. Thanks are due to Mr. Chatterton for the great trouble he has taken in carrying out the comparisons for the Committee, and for his proposition of the draft of Report. Of Mr. Dines's anemometer it may be said that any one having the necessary time and skill, who will turn his attention to the question of the improvement of anemometers, will deserve the best thanks of meteorologists. Simplicity of construction is a thing to be desired, but actual work will, after all, best test the capabilities of an instrument. Of Mr. Whipple's two instruments I would only remark that I should somewhat fear whether the little discs could practically be relied on when there was much wind.

Mr. Rogers Field said he was glad a Committee had been appointed to consider the question of wind force, as it was a question which certainly required consideration, and good results would be obtained from a careful investigation of the whole subject. Eight or nine years ago he had shown that the position of anemometry was bad, and he very much regretted that the subject was still in the same unsatisfactory state. He then proved that the records of the Kew anemometer were incorrect, and, as instruments in this country were generally compared with the Kew standard, it therefore followed that the records of all anemometers so compared were also untrustworthy. The error arose in the following way. The rule for converting the revolutions of the Robinson cups into the equivalent of actual wind movement was incorrect, and consequently all the results based upon this rule were incorrect also. Dr. Robinson believed the cups moved at one-third of the actual wind force, and that therefore the number of revolutions made by the cups required to be multiplied by 3 in order that the true wind movement should be obtained. This factor was first called into question by the Rev. F. W. Stow; then Dr. Dohrandt conducted experiments at St. Petersburg, which showed the factor should be considerably less than 3. Dr. Robinson, disbelieving this result, then carried out some experiments himself at Dublin, in order to prove that Dr. Dohrandt's result was erroneous, but they only corroborated the results obtained in St. Petersburg. A further series of experiments were also carried out by Dr. Dohrandt, which agreed in a remarkable manner with Dr. Robinson's experiments. But this was not all. Some experiments were made many years ago at the Crystal Palace by Mr. Jeffery, then Superintendent of the Kew Observatory, the anemometers being placed on a steam merry-go-round. The observations then made were recently discussed by Prof. Stokes, and the results communicated to the Royal Society (*Proc. Roy. Soc.*, Vol. xxxii. p. 170). These experiments also confirmed the results already obtained by Drs. Dohrandt and Robinson, the agreement of the three series of experiments being very close, as shown by a diagram (which he exhibited to the meeting). Seeing, then, that all these independent investigations agreed in showing that the factor of 3 was wrong, he (Mr. Field) thought that it was highly discreditable to meteorologists to continue to employ this erroneous factor, and allow such an unsatisfactory state of anemometry to exist. He was glad the Committee had abandoned the idea of carrying out experiments with the aid of a locomotive engine, at any rate for the present, and he recommended as the best method of arriving at a proper solution of the whole question, that all the information already at hand should be worked up and discussed, as by that means we should discover what was really required. He entirely agreed with the concluding remarks of Mr. Dines as to the velocity of the wind not being actually so great as was frequently registered.

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[1] *Quarterly Journal Met. Soc.* Vol. viii. p. 189.

[2] *Proc. Inst. C. E.* Vol. lxix. part 3.

Mr. **Laughton** said he entirely agreed with Mr. Field's conclusions, but hoped that now something would be done to put the subject of anemometry in a more creditable position. With reference to what had been said as to the very different indications of small and large cup-anemometers, he believed there was a certain proportion between arms and cups which would render the readings of different patterns of instruments the same, or, at any rate, comparable; but, if so, it had not yet been worked out. He welcomed Mr. Dines's instrument as lifting meteorologists out of the groove of cups, in which they had for so long a time been content to rest. It was a new departure, from which he hoped much good would result. The tube anemometer was one which commended itself to our fancy, but there appeared to be a difficulty in the interpretation of its readings.

Dr. **Marcet** remarked that it would be an advantage if, in the second instrument described by Mr. Whipple, the vane was raised above the top of the circular plate, as in that position it could be more freely acted upon by the wind than if placed immediately at the back of the plate.

Mr. L. F. **Vernon-Harcourt** said that Dr. Robinson altered the constant of his cup anemometer of the large Kew pattern from 3 to 2½ in 1878, therefore, if 3 was still used, the responsibility for its continued use rested with the observers. Mr. Dines's remarks respecting his having never seen the smoke of a locomotive engine driven by the wind in front of a train, even when the wind was blowing from a point immediately behind the train, were, as he had said, based on observations on a railway embankment, and it must be remembered that embankments were usually raised in valleys, where the full force of the wind would not be felt. Some simple anemometer at a small cost was very much required, and he thought Mr. Whipple's instrument would perhaps be useful. Regarding the pressure exerted by the wind, he said that only once had he experienced any serious difficulty in walking against the wind, and that occasion was in March 1871, when he was in Alderney, and although the distance he had to go was short, he arrived at his destination panting for breath. He considered that the wind pressures recorded were not very far from the truth.

Mr. **Archibald** said he had used Biram's anemometers in carrying out experiments with kites, and had found them answer very satisfactorily. As ordinarily made they were not strong enough to withstand any great velocity, and, in fact, he had had them blown to pieces by the action of the wind, but he now had the fans made of brass and found they could withstand a velocity of 30 miles an hour. There was a danger in the case of the Robinson cup anemometer of mixing pressure and velocity, but the Biram instrument being so small the effect of pressure on its indications was extremely slight. He considered that anemometers should be raised above the surface of the ground, so as to be clear of trees and all obstacles which might affect their indications. It was impossible to obtain the true velocity or pressure of the wind by placing instruments near the earth's surface. He could undertake, by means of the kites he had made for purposes of meteorological observations, to raise a small anemometer to 1,000 feet or more. He had already succeeded in raising four instruments, each weighing 1½ lbs., to heights varying from 500 to 1,500 feet.

Mr. **Scott** said that the reason the experiments made with the merry-go-round at the Crystal Palace were not discussed immediately after their completion, was because they were not considered sufficiently numerous to afford reliable results. Prof. Stokes, several years after the carrying out of these experiments, had suggested the advisability of conducting investigations with anemometers in a similar manner, and was then informed of the existence of the Crystal Palace experiments. The observations made were handed over to him, and he ultimately discussed them and embodied the result in a paper read before the Royal Society (*Proceedings*, Vol. xxxii. p. 170). The Meteorological Council had carefully considered the desirability of altering the factor, say, from 3 to 2¼, and had come to the conclusion that the accuracy of the latter factor was not sufficiently established to warrant them in making any alteration.

Mr. **Stanley** exhibited a small and handy form of Lind's anemometer, which he considered would assist observers in making correct estimations of wind force.

Mr. **Strachan** said he would briefly state that the investigation by Prof. Stokes which had been mentioned leads to the conclusion that the constant for small cup-and-dial anemometers, such as the instrument makers usually supply and keep in stock, is 3; but the constant for large anemographs, such as the one at Kew Observatory, and those at the observatories established by the Meteorological Office, is not 3 but 2·4. But all these large anemographs were constructed on the supposition that the correct constant was 3, and consequently their indications are all 25 per cent. too much. The reason why the instruments were not altered is not far to seek. It cannot be contended that the constant 2·4 is satisfactorily settled. Therefore it was best to let them work on as they were, save useless expense, and avoid breaking the continuity of the records. When the constant shall be finally settled the necessary corrections can be applied to the records. Of course it seemed reasonable to expect that for instruments of a medium size, of which there are several patterns, a constant intermediate to 3 and 2·4 would be required. However, this must be experimentally determined. Thus it comes to pass that small anemometers give less than they should do, owing to defective exposure, while large ones, which are usually well exposed, give too much, from the use of an erroneous constant. But this was not the only defect of anemographs, which register the direction as well as the velocity. Their records of direction were faulty also, for the windmill governor of the vane is so massive that no force of wind under 3 of the Beaufort scale can overcome its inertia. This is an important defect, since it is equally necessary for the researches into the movements of the atmosphere to know the direction as well as the velocity of the wind continuously.

Mr. C. **Harding** referred to the value of the work performed by Mr. Chatterton in his comparison of the wind force by Beaufort scale at the lighthouses and on board the lightships with the velocities recorded by the anemographs at Holyhead, Falmouth and Yarmouth. He thought the agreement between the Carnarvon Bay Light Vessel and South Stack Lighthouse and the records of the anemograph at Holyhead very interesting. He had seen Mr. Dines's anemometer in operation, and was of opinion that it worked very satisfactorily. He had also seen the whirlabout apparatus used by Mr. Dines for testing his instruments. It was a very rigid, but, at the same time, light structure, and had no tendency to "churn up" the air during its rotation. It appeared to be very suitable for the testing of small instruments, but would require to be strengthened if it was desired to use it for whirling large-sized anemometers. He considered the loaded boxes used by the late Mr. G. Dines for registering wind pressure were exceedingly ingenious. It might be worth while to arrange a series of such boxes on poles, at various elevations above the ground, as he believed some interesting results might be obtained by this means. He was of opinion that very little value could be attached to the Crystal Palace merry-go-round experiments discussed by Prof. Stokes, as from his own knowledge of the position of the apparatus he considered the spot was ill-adapted for any satisfactory experiments, and the merry-go-round itself was cumbersome and likely to cause a considerable "churning up" of the air in its vicinity during rotation. The Meteorological Council had acted wisely in not altering the factor for the present. He hoped the Committee appointed by the Society would be able to determine the whole question in a satisfactory manner.

Capt. WILSON-BARKER said the forms of anemometers now generally in use required to be mounted in a very substantial manner on stone supports, and these caused a great deal of deflection and disturbance of the wind. The instruments could be mounted on iron trellis-work pillars, which afforded very little resistance to the wind, but even then instruments would vary, from the friction of their working parts. The anemometer which seemed the simplest and best adapted for exposure was the Hagemann form, for in this instrument the tube connected to it could be run up 15 or 20 feet, or even more, above any building, and the resistance the tube offered to the air was very slight.

Mr. CHATTERTON said the Committee did not see how any extensive series of experiments could be carried on owing to the great expense which would be incurred. So far as the results of the comparison contained in the table in the Report were concerned, the best results were those from the Holyhead anemograph and the Carnarvon Bay Lightship and South Stack Lighthouse. So far as present investigations had gone, the Committee had found the whole subject in a very unsatisfactory state, and in fact they must be considered as only just commencing their investigations.

Mr. W. H. DINES said that he thought that the highest pressure which had been experienced on his father's tower was 9 lbs. to the square foot, but that he could not speak positively at the moment. With regard to the suggestion that railway embankments generally occurred in sheltered valleys, he could say that the two on which he had had special opportunities of noticing the matter were not in the smallest degree open to that objection. The one was between Hayward's Heath and Burgess Hill on the South Coast Railway; it was about one mile in length, and included a viaduct, and from it there was a splendid view. The other was between Surbiton and Walton on the South Western main line; it was five miles in length, the country on one side was a dead flat for miles, and on the other, the Surrey Hills, ten to fifteen miles distant, could be seen. No one who had passed over it in a gale could doubt the fulness of the exposure. With regard to the constant of Robinson's anemometer, he did not think it was advisable to alter the construction of the clockwork train at present, for he did not consider that the proper constant had been determined; especially as no direct experiments had as yet been made at high velocities. He thought it probable that when these experiments were made, it would be found that the constant was different, perhaps very different, for different rates. He had placed a similar instrument to that exhibited to the meeting on top of a pole on a tower attached to a house. The instrument being light, could be sent up and down the pole somewhat in the same way as a flag was raised or lowered. He considered the top of a building a very unsatisfactory place on which to expose an anemometer, as, to say the least, it was very liable to eddies.

Mr. WHIPPLE said the actual pressure or velocity of the wind might not be of very much importance to meteorologists, but maximum pressures are required to be known by engineers in order that structures may be erected of sufficient strength to withstand such pressures. The question of the true value of the factor for the Robinson cups was therefore an important one in this respect, as thereotically the pressure varied as the square of the velocity, and the factor being wrong would greatly affect the conversion of velocities into their equivalent pressures. With regard to the Holyhead Observatory and South Stack Lighthouse observations, he said he could not attach much weight to the results obtained, as he did not consider the position and surroundings of the observers were strictly comparable at the two stations. The exposure of the Yarmouth anemometer was also not good, for reasons given in the Paper. He especially emphasised the absolute necessity of constant oiling and attendance to the cleanliness of anemometers, as it was a most important point and materially affected their working. The advantage attaching to Mr. Dines's beautiful little instrument was that friction had very little effect upon its working, as he had seen by witnessing an actual experiment.

EXHIBITION OF MARINE METEOROLOGICAL INSTRUMENTS,

HELD, BY PERMISSION OF THE COUNCIL OF THE INSTITUTION OF CIVIL ENGINEERS, AT 25 GREAT GEORGE STREET, WESTMINSTER, S.W.,

MARCH 15TH-18TH, 1887.

INSTRUMENTS FROM DIFFERENT INSTITUTES.

FROM THE "CHALLENGER" COMMISSION; THE SCOTTISH MARINE STATION; THE SCOTTISH METEOROLOGICAL SOCIETY; AND MR. J. Y. BUCHANAN.

1. **Miller-Casella Deep-sea Thermometer, "Challenger" pattern,** registering degrees of equal length on maximum and minimum sides.
2. **Minimum registering Deep-sea Thermometer,** the long cylindrical bulb and the maximum limb encased in vulcanite.
3. **Miller-Casella Deep-sea Thermometer improved by Mr. Buchanan.** The minimum limb is of narrow bore, and the tube has an arbitrary (millimetre) scale etched upon it. The maximum limb is of wide bore and has a great range.
4. **Miller-Casella Deep-sea Thermometer** after four months' immersion, at the surface, in brackish water. The copper case is clean, but the scale figures are entirely obliterated from the porcelain.
5. **Miller-Casella Deep-sea Thermometer** after four months' immersion at the bottom, in 9 fathoms of brackish water. Suspended so as to remain 1 foot above the bottom at all states of tide. The copper is entirely covered with a green crust, but the scale figures are not rendered illegible.
6. **Cistern Thermometer** used by the late Sir Robert Christison in Loch Lomond. A metal box with a thermometer in the centre, three holes in the lower side and three cone-and-ball valves in the upper side, to admit a circulation of water during descent only.
7. **Magnaghi's Frame for Negretti and Zambra's Reversing Thermometer.** The reversing gear is a fan actuated by the current of water in raising the instrument.
8. **Scottish Frame for Negretti and Zambra's Reversing Thermometer** Used at the Scottish Marine Station and by the Fishery Board for Scotland. Adapted from Magnaghi's by Dr. Mill. The reversing gear is a lever actuated by one of Capt. Rung's messengers. The frame is fixed to the sounding-line by a vice-clamp and spiral wire. (This instrument is shown by Messrs. Negretti and Zambra.)
9. **Improved Frame for Reversing Thermometers,** adapted from the Scottish frame by Mr. J. Y. Buchanan.
10. **Sea-thermometer for use on Fishing Boats,** formerly used by the Scottish Meteorological Society.

11. **Surface Thermometer,** as used at the Scottish Marine Station.

12. **Stevenson's Box for Self-registering Thermometers in Rivers,** recommended by the Scottish Meteorological Society.

13. **Sling Thermometer,** for observing temperature of air at sea.

14. **Observation Cards and Book** used at the Scottish Marine Station.

15. **Piezometer.** For ascertaining the depth when temperature is known or temperature when depth is known. Double water-piezometer, experimental form.

16. **Water-Piezometer, two tubes.** Constructed by Mr. Buchanan on board the *Challenger*.

17. **Water-Piezometer, single tube.** Constructed by Mr. Buchanan on board the *Challenger*.

18. **Mercury-Piezometer,** constructed by Mr. Buchanan on board the *Challenger*.

19. **Mercury-Piezometer,** improved form.

20. **Stop-cock Water Bottle.** Used on the *Challenger* for collecting samples of water at intermediate depths. The large stop-cocks (one at each end) are connected by levers, which are actuated by the pressure of the external water on a metal plate during ascent. When the stop-cocks are closed the plate falls flat and offers no further resistance.

21. **Slip Water Bottle.** Used on the *Challenger* for collecting samples of water from the bottom. The bottle closes on striking the ground.

22. **Buchanan's Sounding Rod and Water Bottle** (shown in action). When the sounding tube strikes the bottom, the weight is discharged; the tube fills with a sample of mud or ooze, which is retained by a metallic fringe, and acts as a stopper to the valved water bottle forming the upper part of the sounding-rod.

23. **Buchanan's Slip Water Bottle for Shallow Water.** The body of the water bottle is lowered to the required depth and the slip part allowed to run down the line. The edge of the slip cylinder presses on an india rubber ring, and by its weight keeps in the water.

24. **Mill's Self-locking Slip Water Bottle.** The sounding line passes through the axis of the bottle. The slip cylinder is held up by springs which are withdrawn by the impact of a weight dropped from above. The slip falls and rests on a rubber ring below, while its flanged upper rim presses on a rubber disc; at the moment of striking, two springs emerge, press on the neck of the cylinder from above, and keep it firmly down.

25. **Bottle arranged for collecting Water-samples** in shallow estuaries.

26. **Portable Hydrometer, for Boat Work,** as used for measuring salinity at the Scottish Marine Station.

27. **Hydrometer, "Challenger" type,** with weights to adapt it for water of any salinity. The instrument is weighted and calibrated, and from the temperature, the immersed volume, and the total weight of the loaded hydrometer, the density of the water is calculated.

28. **Navigational Sounding Machine,** devised by Mr. Buchanan.

28*. **Pressure Gauge** employed by Prof. Tait for measuring the compressibility of water at various temperatures. Used on board H.M.S. *Triton*, by Prof. Chrystal and Mr. Murray.

FROM THE METEOROLOGICAL COUNCIL.

29. **Specimen Set of Instruments supplied to Merchant Ships,** viz.:—Barometer, Thermometers, Hydrometers, Thermometer Screen, Meteorological Log, Rough Book, and Instructions.

30. **Specimen Set of Instruments supplied to H.M. Ships,** viz.:—Barometer, packed with india-rubber tubing to withstand gun-firing; Aneroid; Maximum and Minimum Thermometers (for use in chronometer room). The thermometers, hydrometers and screens are similar to those supplied to Merchant Ships.

31. **Marine Barometer,** by Newman, used for the Meteorological Register kept on board H.M.S. *Resolute,* 1850-51. It reads correctly with the Meteorological Office Standard, but the tube is not sufficiently contracted for a marine barometer.

32. **Marine Barometer,** by Dennis, as supplied to H.M. Ships previous to 1854. It was used for the Meteorological Register kept on board H.M.S. *Rattlesnake* during a voyage to Behring Strait, including wintering at Port Clarence, 1853-55.

33. **Marine Barometer Tube,** packed with india rubber, to show construction of the Gun Barometer supplied to H.M. Navy.

34. **Marine Barometer,** by Ernst, the pattern used in the French Navy in 1860.

35. **Aneroid Barometer by Dent.** A specimen of the pattern of Aneroid supplied to H.M. Ships previous to 1854.

36. **Johnson's Registering Metallic Deep-sea Thermometer,** the records of which are obtained by the varying expansion of brass and steel bars acting upon indices.

37. **Deep-sea Thermometer** made for Sir James Ross by Pastorelli.

38. **Deep-sea Thermometer.** Six's pattern by Potter.

39. **Deep-sea Thermometer.** Six's pattern, with protected tube.

40. **Deep-sea Thermometer,** French Pattern.

41. **Nicholson's Hydrometer,** supplied to Sir J. C. Ross's Expedition to the Antarctic Regions in 1839. With this instrument a set of weights is supplied.

42. **Apparatus for ascertaining the Temperature and Specific Gravity** of the sea, used by the *Kommission zur Untersuchung der deutschen Meere.*

43. **Sir Snow Harris's Wind Gauge.** An improved form of Lind's Anemometer.

44. **Hagemann's Anemometer.**

45. **Hand Anemometer,** devised by F. Galton, F.R.S.

FROM THE ROYAL METEOROLOGICAL INSTITUTE OF THE NETHERLANDS.

46. **Marine Barometer,** by Olland, as used in the Dutch Navy. The cistern is of cast iron, the mounting of brass.

47. **Aneroid** as supplied to the ships of the Dutch Navy. This instrument is not compensated for changes in temperature.

48. **Pyschrometer** as supplied to ships of the Dutch Navy.

49. **Thermometers for Sea Surface Temperature.** These are ordinary thermometers enclosed in a metal case to protect the instrument.

50. **Areometers (Hydrometers) as supplied to Ships of the Dutch Navy.** The box contains two areometers and a thermometer. Areometer No. 1 is for Specific Gravities of from 1000 to 1020; and No. 2 of those from 1020 to 1040. By adding a small glass weight to No. 1, the readings become the same as from No. 2.

51. **Water Bottle for collecting Samples of Water** at any required depth below the surface. This consists of a copper cylinder provided with a strong brass hoop at the top. This hoop bears a ring at its upper part, which is attached to the deep-sea line, and serves to support the top of the leading rod for bottom and top valve, which passes through the centre and is fixed at the lower end to a brass cross-bar. In the perpendicular sides of the hoop are two springs, which keep the valves open when the instrument is being lowered. On the instrument being hauled up, the valves are shut water-tight by the downward pressure of the water.

FROM THE LOCHBUIE MARINE INSTITUTE.

52. **Instruments used at the Lochbuie Marine Institute, Isle of Mull** :—
    1. Miller-Casella Deep-sea Thermometer, with buoy attached for bottom temperature.
    2. Bath Thermometer for surface temperature.
    3. Thermometer to be used with a tow net.
    4. Sling Thermometer for Air Temperature on smacks and fishing boats where no screen can be fixed.
    5. Disc for ascertaining the transparency of the sea.
    6. Dimenuon Thermometer in box for River Temperature. This box is suitable for the bottoms of pools, or rough stony bottoms.
    7. An observer's case with directions and cards for observation.

Exhibited by the Rev. C. J. Steward, M.A., F.R.Met.Soc.

BAROMETERS.

53. **Marine Barometer,** with iron cistern and contracted scale.
Exhibited by Messrs. Negretti and Zambra.

54. **Gun Barometer,** mounted with india-rubber packing to prevent breakage caused by gun firing. *Exhibited by* Messrs. Negretti and Zambra.

55. **Fisherman's Aneroid** as supplied to the Royal National Lifeboat Institution.
Exhibited by Messrs. Negretti and Zambra.

56. **Sympiesometer.** An original instrument by Adie of Edinburgh, made about 1830. Refilled and repaired by Bywater, Dawson & Co., Liverpool, about 1842, and in action ever since.
Exhibited by R. J. Lecky, F.R.Met.Soc.

DEEP SEA THERMOMETERS.

57. **Negretti and Zambra's Recording Deep-sea Thermometer.** This consists of a turnover Thermometer which has its bulb protected by an outer cylinder. The Thermometer is attached to a frame with a vertical propeller. In its descent through the water the propeller is lifted out of gear and revolves freely on its axis; but as soon as the apparatus is pulled up towards the surface the propeller falls into gear and revolves in the contrary direction, turning the Thermometer over once, and then becoming locked and immovable, thus records the temperature at the lowest depth reached. *Exhibited by* Messrs. Negretti and Zambra.

58. **Negretti and Zambra's Marine Thermometer for shallow depths.** A turnover Thermometer is fitted into a wooden frame loaded with shot free to move from end to end of it, and heavy enough to render the instrument just buoyant in sea water.
Exhibited by Messrs. Negretti and Zambra.

59. **Deep-sea Thermometers** used by the India Rubber, Gutta Percha, and Telegraph Co., Limited, of Silvertown, in their sounding operations in the North Atlantic.
    1. Deep-sea Thermometer by L. Casella.
    2. " " " Negretti & Zambra.

Exhibited by Capt. D. Wilson-Barker, F.R.Met.Soc.

60. **Apparatus originally employed in testing Deep-sea Thermometers** for the Admiralty and Royal Society, and damaged during the experiments, viz.:—
    1. Bottle broken at a pressure corresponding to 2½ miles of sea water.
    2. Steel Bar bent " " " 3 " " "
    3. Iron Plug broken " " " 4 " " "

Exhibited by L. P. Casella, F.R.Met.Soc.

ANEMOMETERS.

61. **Hagemann's Anemometer,** adapted for special use on board ship by R. J. L. Ellery, F.R.S. Coloured water is to be poured into the tube till it is level in both arms with the zero. The instrument is then held up, with the bell mouth facing the wind. The wind blowing into the bell mouth and over the open tube causes the water to fall in one arm and rise in the other.
Exhibited by Capt. D. WILSON-BARKER, F.R.Met.Soc.

62. **Robinson's Anemometer** adapted for special use on board ship by R. J. L. Ellery, F.R.S. The anemometer is to be held at arm's length, above the head, on the bridge or other exposed position on the ship, and the number of revolutions of the dial made in 30 seconds read off.

The velocities as derived from these instruments have to be corrected for the ship's speed and the angle between the wind's direction and the course of the ship. The tables in use for these instruments were prepared by comparing them with the Standard Instruments at the Melbourne Observatory. *Exhibited by* Capt. D. WILSON-BARKER, F.R.Met.Soc.

63. **Marine Anemometer.** This consists of a mast and sail, on which the wind acts and conveys the pressure to a spring coil and index travelling on a scale. By means of the scale the pressure in lbs. per square foot and velocity in miles can be read off. A self-registering plate and pencil can be affixed to the scale when required. The vane indicates the direction of the wind, which can be read in degrees on the dial at the foot.
Exhibited by Surg.-Maj. W. G. BLACK, F.R.Met.Soc.

64. **Wind Circle or Estimator.** This consists of a disc of wood marked with the points of the compass and also with degrees, and of five scales to fit on the central pivot for solving the problem of the wind on board ship by parallelogram and diagonal. Arm A shows the course and rate of the ship in miles per hour by the pin screwed in the holes; B. Velocity of apparent wind; C. Complement of true wind; D. Complement of ship's course and rate; and E. True wind, direction and velocity. *Exhibited by* Surg.-Maj. W. G. BLACK, F.R.Met.Soc.

MISCELLANEOUS.

65. **Marine Rain-gauge and Evaporator.** This consists of a square box holding a cylindrical rain collector and receiver, 6 ins. diameter, poised upon an upright pivot in the centre. The amount of rainfall is measured in the usual way. The evaporating dish is cylindrical, of 6 ins. diameter and should hold 1 inch depth of water, to be measured off daily.
Exhibited by Surg.-Maj. W. G. BLACK, F.R.Met.Soc.

66. **Frame for Rotatory Thermometer** to be used at sea, by Dr. W. Köppen.
Exhibited by Dr. NEUMAYER.

67. **Psychrometer-stand and Table** for making magnetic observations at sea.
Exhibited by Dr. NEUMAYER.

68. **Patent Logs** used for determining speed of ships :—
(1) Bliss's patent log; (2) Walker's towing log; (3) Walker's harpoon log; (4) Massey's towing log.
Exhibited by Capt. D. WILSON-BARKER, F.R.Met.Soc.

69. **Massey's Patent Current Meter.** This is to be made fast to a buoy or boat which is anchored.
Exhibited by Capt. D. WILSON-BARKER, F.R.Met.Soc.

70. **Current Meter** for ascertaining the tidal rate or flow of streams or rivers. This instrument can also be used as a log to determine the rate of a ship's speed. *Exhibited by* Messrs. NEGRETTI AND ZAMBRA.

71. **Marine Clinometer** to indicate the amount of rolling.
Exhibited by Messrs. NEGRETTI AND ZAMBRA.

72. **Berthon's Sensitive Clinometer** for showing the exact trim of the ship.
Exhibited by L. P. CASELLA, F.R.Met.Soc.

73. **Hicks and Tight's Marine Clinometer.**
Exhibited by J. J. HICKS, F.R.Met.Soc.

74. **Leigh Smith's Four-arc Sextant** for the solution of questions in Spherical Trigonometry where the three sides of a triangle are given.
Exhibited by L. P. CASELLA, F.R.Met.Soc.

75. **Planispherio,** for solving problems in navigation, by Capt. J. C. de Brito Capello. *Exhibited by the* METEOROLOGICAL COUNCIL.

76. **Model of Section of a Vessel fitted with Lightning Conductor.**
Exhibited by Messrs. J. W. GRAY & SON.

INSTRUMENTS NEW, OR NOT PREVIOUSLY EXHIBITED.

77. **Richard's Self-recording Aneroid.** This instrument consists of a series of vacuum boxes by which the effects of the atmospheric pressure are increased and transmitted by a system of levers to an arm carrying a pen. This instrument can be used on board ship.
Exhibited by MM. RICHARD FRÈRES.

78. **Richard's Thermograph.** The thermometer consists of a very thin curved metal case (a Bourdon tube) containing alcohol, one end being a fixture and the other movable. As the alcohol expands or contracts with the changes of temperature it alters the curve of the tube, making it flatter or otherwise. The movable end of the tube responds to these alterations, and communicates them by means of a metal rod to a lever carrying a pen, which inks correspondingly on a graduated paper wound on a cylinder, containing a clock which turns it round once in seven days.
Exhibited by MM. RICHARD FRÈRES.

79. **Richard's Self-recording Hygrometer.** *Exhibited by* MM. RICHARD FRÈRES.

80. **Richard's Self-recording Dry and Wet Bulb Thermograph.** This consists of a pair of thermometers similar to No. 78, which are placed side by side; but they are curved reversely and are placed as far apart as possible. The wet-bulb thermometer is covered with muslin, and is kept moist by a water vessel below into which the muslin dips, and also by a capillary siphon from a second water vessel above.
Exhibited by MM. RICHARD FRÈRES.

81. **Watkin Aneroid with open scale.** Instead of the usual one-circle of figures the scale of this instrument consists of a spiral of three complete turns. On the aneroid being put under an air pump or taken up a mountain, the point of the index is gradually drawn *towards* the centre, so that it follows the *decreasing* spiral scale; but when the index moves in the opposite direction the point moves *away* from the centre, thus following the *increasing* spiral. This is effected by the index-hand being made to slide in and out, so that one end may advance or recede from the centre and thus follow the spiral scale. Attached to the spindle is a cross piece, in which the index slides, and a hollow drum fixed to the dial plate has a flexible chain or cord wound round it, the ends being fastened to the projecting pins rivetted to the index; consequently, if the spindle and the piece attached to it are revolved, one portion of the chain or cord winds off the drum, the other being wound-on to the same extent, and the index is caused to slide through the cross piece, the direction of motion being controlled by the direction in which the spindle is revolved. *Exhibited by* J. J. HICKS, F.R.Met.Soc.

82. **Watkin Aneroid** with three concentric scales, and in combination therewith a hand or pointer sufficiently long to extend across all the circles, the main hand having three smaller hands attached to it, each of which

points to a separate circle. In order to show clearly which scale should be read, there is an indicator attached to the movement of the instrument which causes a series of figures, I. II. III. (corresponding to the three circles), to be exhibited through an aperture in the dial. *Exhibited by* J. J. Hicks, F.R.Met.Soc.

83. **Self-registering Thermometers** with lens-front tube. *Exhibited by* J. J. Hicks, F.R.Met.Soc.

84. **Meteoric Dust Collector.** Devised by Dr. Arthur Mitchell. A box containing three screens of fine platinum wire to be placed so that the wind blows (or a current of air is aspirated) across the wires. After a sufficiently long exposure the screens are washed with distilled water and the dust is carried into a bottle, in which it is allowed to settle. The water is decanted off and the dust examined microscopically. *Exhibited by* H. R. Mill, D.Sc., F.R.S.E.

85. **Models of two Maximum Pressure Anemometers.**

No. 1 consists of four radially placed inverted glass siphons which indicate the maximum wind pressure by the extent of paper strips discoloured by the changes of the water level in the tubes.

No. 2. Eight small metal discs, each of 0·01 ft. in area, are supported vertically against the wind by levers weighted in accordance with the various pressures of the wind. By their displacement the maximum wind pressure is registered. (See p. 224.) *Exhibited by* G. M. Whipple, F.R.Met.Soc.

DIAGRAMS, PHOTOGRAPHS, &c.

86. **Atlas des Mouvements generaux de l'Atmosphere,** année 1864, Juin-Décembre. Rédigé par l'Observatoire Impérial de Paris. (1868.) *Exhibited by the* Royal Meteorological Society.

87. **Wind and Current Charts** for the Pacific, Atlantic and Indian Oceans. Published by the Hydrographic Office (1872). *Exhibited by the* Royal Meteorological Society.

88. **Synoptic Weather Charts of the Indian Ocean** for the month of February 1861. Prepared and published under the auspices of the Meteorological Society of Mauritius. *Exhibited by the* Royal Meteorological Society.

89. **Meteorological Charts of the North Pacific Ocean** from the Equator to Lat. 45° N, and from the American Coast to the 180th Meridian; giving information regarding Winds, Calms, Fog, Rain, Squalls, Weather, Barometer, and the Temperature of the Air and of Sea water at the surface; all for every five-degrees square, and for every month. Published by the Hydrographic Office, Washington (1878). *Exhibited by the* Royal Meteorological Society.

90. **Atlantischer Ozean.** Ein Atlas von 36 Karten, die physikalischen Verhältnisse und die Verkehrs-Strassen darstellend, mit einer erläuternden Einleitung und als Beilage zum Segelhandbuch für den atlantischen Ozean. Herausgegeben von der Direktion der Deutschen Seewarte (1882). *Exhibited by the* Royal Meteorological Society.

91. **Segelhandbuch fur den Atlantischen Ozean.** Herausgegeben von der Direktion der Deutschen Seewarte (1885). *Exhibited by the* Royal Meteorological Society.

92. **Cartes Synoptiques Journalieres du Temps, embrassant le Nord de L'Atlantique** et une partie des Continents avoisinants. Publiées par L'Institut Météorologique Danois et le Deutsche Seewarte. *Exhibited by the* Royal Meteorological Society.

93. **Specimens of Daily Synchronous Weather Charts of the North Atlantic,** viz.:—(1) August 1st-6th, inclusive, showing meteorological conditions in the summer; (2) February 9th-14th, showing conditions in the winter; (3) February 24th-March 4th, showing persistence of the European anti-cyclone in the early spring and resulting cold dry winds in England.

The height of the Barometer is indicated by colours, according to the following scale:—Below 29·0ins. darkest blue; 29·0 to 29·4in. medium blue; 29·4 to 29·8ins. light blue; 29·8 to 30·0ins. uncoloured; 30·0 to 30·3ins. light pink; 30·3 to 30·6ins. medium pink; above 30·6ins. darkest pink. *Exhibited by the* METEOROLOGICAL COUNCIL.

94. **Specimens of Mean Pressure and Sea Temperature Charts of the Atlantic Ocean** for the months of February and August.
Exhibited by the METEOROLOGICAL COUNCIL.

95. **Charts exhibiting for the Month of January the Meteorological data for the Red Sea.** The results derived from the Meteorological Office Logs, and the logs lent respectively by the Royal Meteorological Institute of the Netherlands and the Peninsular and Oriental Company, are represented separately, with the object of showing the amount of agreement between different observers.
Exhibited by the METEOROLOGICAL COUNCIL.

96. **Charts showing Mean Temperature of the Sea Surface** round the coasts of the British Isles for each month.
Exhibited by the METEOROLOGICAL COUNCIL.

97. **Diagram showing difference of Curves of Vertical Distribution of Temperature,** as ascertained by reversing thermometers and by maximum and minimum self-registering instruments.
Exhibited by H. R. MILL, D.Sc., F.R.S.E.

98. **Diagrams showing the Distribution of Temperature** in a section of the Clyde Sea Area at seven periods, from April 1886 to February 1887, compiled by Dr. Mill, from materials collected by the Staff of the Scottish Marine Station. *Exhibited by* H. R. MILL, D.Sc., F.R.S.E.

99. **Photographic Registers of Magnetic Declination and Horizontal Force** at the Royal Observatory, Greenwich, showing the Earthquake shock which occurred on the morning of February 23rd, 1887.
Exhibited by W. H. M. CHRISTIE, F.R.S., Astronomer Royal.

100. **Photographs, &c., of Instruments used at the Ufficio Centrale di Meteorologia, Rome**:—
1. The Counter of the Anemometer in two positions.
2. The Wind Rose of the Anemograph.
3. The Cups.
4. The Vane.
5 and 6. Two different views of the typographic Anemograph.
7 and 8. Two views of the New Anemograph.
9. Psychrometer and Evaporimeter.
10. New Self-recording Rain-gauge.
11. Anemoscope et Anémomètre à transmission libre.
12. Anemoscopio ed Anemometro a transmissione elettrica.
13. Igrometro ad Appannamento modificato dal Dr. C. Christoni.
14. L'Udometro-contatore.
15. Catalogo descrittivo degli istrumenti Sismici.
16. Reotomo a Sabbia. *Exhibited by* PROF. P. TACCHINI.

101. **Erdprofel,** Zone from 31° to 65° N lat. By Capt. Lingg of Munich.
Exhibited by the METEOROLOGICAL COUNCIL.

102. **Charts of Jordan's Sunshine Recorder** from October 22nd, 1886, to March 14th, 1887. *Exhibited by* F. C. BAYARD, F.R.Met.Soc.

103. **Curves taken at Sea by Richard's Barograph** in various parts of the world. *Exhibited by the* Hon. R. ABERCROMBY, F.R.Met.Soc.

104. **Forty-six Photographs and Diagrams of Clouds** taken in various parts of the world. *Exhibited by the* Hon. R. ABERCROMBY, F.R.Met.Soc.

105. **The Chromatics of the Sky.** Coloured drawings of Clouds and other atmospheric phenomena, with observations, 1886-1887; with the object of assisting in weather prediction. (Fifth Series.) *Exhibited by* J. S. DYASON, F.R.Met.Soc.

106. **Four Chromo-Lithographs,** copied from Mr. Dyason's original drawings of skies, showing the practicability of their reproduction. *Exhibited by* J. S. DYASON, F.R.Met.Soc.

107. **Twelve Isochromatic Photographs** of Mr. Dyason's drawings of skies, taken by a method giving the correct 'tone values' of the various colours. Photographed by Withans, Keating & Co. *Exhibited by* J. S. DYASON, F.R.Met.Soc.

108. **Photographs of the Stations of the Royal Meteorological Society** taken by Mr. W. Marriott during his Inspections 1884-1886. *Exhibited by the* ROYAL METEOROLOGICAL SOCIETY.

109. **The Fair and Foul Weather Prognosticator,** being a table for foretelling the weather, through all the Lunations of each year for ever. Recommended by Rev. Adam Clark, LL.D., F.A.S. (Printed in 1825). *Exhibited by* F. B. EDMONDS, F.R.Met.Soc.

110. **The London Daily Papers and the Weather.** Methods of indicating the weather, adopted by the various London Daily Newspapers. *Exhibited by* J. STOKES, F.R.Met.Soc.

WILLIAM ELLIS, F.R.A.S., *President.*
G. J. SYMONS, F.R.S. } *Secretaries.*
JOHN W. TRIPE, M.D. }
WILLIAM MARRIOTT, *Assistant Secretary.*

INSTRUMENTS RECEIVED TOO LATE FOR INCORPORATION IN THE CATALOGUE.

111. **Specimen Set of Instruments supplied to the German Navy,** viz.:— Barometer, Thermometers, Thermometer Screen, Log Books, Instructions, Forms, &c. *Exhibited by the* DEUTSCHE SEEWARTE.

112. **Apparatus with electrical arrangement for collecting samples of water** at great depths below the surface, and also ascertaining the temperature. *Exhibited by the* DEUTSCHE SEEWARTE.

113. **Richard's Self-recording Rain-gauge.** *Exhibited by* MM. RICHARD FRÈRES.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

MARCH 16TH, 1887.

Ordinary Meeting.

WILLIAM ELLIS, F.R.A.S., President, in the Chair.

GEORGE EYRES, Suva, Fiji;
JOHN TURNER HOTBLACK, 45 Newmarket Road, Norwich; and
Capt. CHARLES H. M. KENSINGTON, R.E., New Brompton, Chatham,
were balloted for and duly elected Fellows of the Society.

The following Papers were read, viz.:—

"NOTES ON TAKING METEOROLOGICAL OBSERVATIONS ON BOARD SHIP." By Capt. D. WILSON-BARKER, F.R.Met.Soc. (p. 185.)

"MARINE TEMPERATURE OBSERVATIONS." By HUGH ROBERT MILL, D.Sc., F.R.S.E. (p. 192.)

On the motion of Mr. INWARDS, seconded by Mr. LAUGHTON, the thanks of the Society were given to the Exhibitors for the loan of their Instruments, &c.

The Meeting was then adjourned in order to afford the Fellows an opportunity of inspecting the Exhibition of Marine Meteorological Instruments and Apparatus which had been arranged in the Library of the Institution of Civil Engineers. The List of Exhibits will be found on p. 230.

APRIL 20TH, 1887.

Ordinary Meeting.

WILLIAM ELLIS, F.R.A.S., President, in the Chair.

ROBERT BARNES, M.D., F.R.C.P., 15 Harley Street, W.; and
LEE LATROBE LATROBE BATEMAN, Torreno, Palma, Majorca,
were balloted for and duly elected Fellows of the Society.

The following Papers were read, viz.:—

"THE STORM AND LOW BAROMETER OF DECEMBER 8TH AND 9TH, 1886." By CHARLES HARDING, F.R.Met.Soc. (p. 201.)

"REPORT OF THE WIND FORCE COMMITTEE." Drawn up by G. CHATTERTON, M.A., M.Inst.C.E., F.R.Met.Soc. (p. 215.)

"A NEW FORM OF VELOCITY ANEMOMETER." By W. H. DINES, B.A., F.R.Met.Soc. (p. 218.)

"DESCRIPTION OF TWO MAXIMUM PRESSURE REGISTERING ANEMOMETERS." By G. M. WHIPPLE, B.Sc., F.R.Met.Soc. (p. 224.)

RECENT PUBLICATIONS.

American Meteorological Journal. A Monthly Review of Meteorology, Medical Climatology and Geography. April-June 1887. 8vo.

The principal original articles are :—Atmospheric Electricity, by A. McAdie (21 pp.).—Wind and Barometer, by H. Allen (5 pp.).—Why does the Barometer rise and fall? by A. Ramsay (6 pp.).—Popular Errors in Meteorology, by Prof. Cleveland Abbe (10 pp.).—Thunderstorms in Southern Russia, by A. McAdie (3 pp.).—Loomis's Contributions to Meteorology, by H. H. Clayton (12 pp.).—Tornado Predictions and their Verification, by G. E. Curtis (7 pp.).—The Distribution of the Weather in Storms and Anticyclones as affected by local influences, by H. H. Clayton (8 pp.).—Reduction of Air Pressure to Sea-level, by H. A. Hazen (12 pp.).

Annuaire de la Société Météorologique de France. Tome XXXV. 1887. January-February. 4to.

The chief papers are :—Du rôle de la vapeur d'eau dans l'atmosphère, par M. Hauvel (6 pp.).—Note sur le nombre et la durée des pluies à Paris, par M. Hervé-Mangon (9 pp.).—Compte rendu du Service hydrométrique du bassin de la Seine pour 1885, par M. Remise (2 pp.).—Résumé des observations centralisées, par le Service hydrométrique du bassin de la Seine, pendant l'année 1885, par H. Heude (38 pp.).

Behm's Geographisches Jahrbuch. Vol. XI. 8vo. 1887.

Contains :—Bericht über die Fortschritte der geographischen Meteorologie, von Dr. J. Hann (74 pp.). This is Dr. Hann's usual biennial report on the progress of Geographical Meteorology during the two years 1884 and 1885, which gives an account of nearly all the meteorological papers that have been published during that period.

Bibliothèque Universelle. Archives des Sciences Physiques et Naturelles. Troisième Période. Tome XVII. No. 5. May 1887. 8vo.

Contains :—Comparaison des indications du thermomètre à boule mouillée dans l'après-midi et le minimum de température pour différents lieux, par A. Kammermann (13 pp.). The author asserts that the difference between the mean temperature of the wet bulb thermometer at a fixed hour and the minimum temperature diminishes with latitude, and varies inversely with the height. This affords an excellent rule for predicting hoar-frosts, &c.

Ciel et Terre. Revue populaire d'Astronomie, de Météorologie, et de Physique du Globe. April-June 1887. 8vo.

The principal meteorological articles are :—Vitesse et direction des orages en Italie, par C. Ferrari (6 pp.).—La nébulosité du ciel à la surface du globe, par L. Teisserenc de Bort (4 pp.).—La nouvelle Observatoire d'Uccle, près Bruxelles, par J. Vincent (5 pp.).

Das Wetter. Meteorologische Monatschrift für Gebildete aller Stände. Herausgegeben von Dr. R. **Assmann.** Vol. IV. Parts 4-6. April-June 1887. 8vo.

Contains :—Die Vorausbestimmung des Nachtfrostes, von Dr. E. Lang (15 pp.).—Die Regenverhältnisse Indiens und des Indischen Oceans, verglichen mit jenen der Tropenzone überhaupt, von Prof. W. Köppen (8 pp.).—Gedanken über die Mitwirkung elektrischer Erdströme bei der Ausbildung der Cyklonen und Wetterphänomene überhaupt, von F. G. von Friesenhof (7 pp.).—Ueber Windfahnen mit horizontaler Achse, von Dr. Vettin (3 pp.).

Journal of the Asiatic Society of Bengal. Vol. LV. Part II. No. 4. 1886. 8vo. 1887.

Contains :—On Solar Thermometer Observations at Allahabad, by S. A. Hill, B.Sc. (6 pp.). The author says that if his results are to be trusted they show that, during the cycle of visible change on the sun's surface, there is a cyclical variation of large range in the heat emitted by the sun, the maximum of emission coinciding with, or perhaps slightly preceding, the phase in which his surface is most uniformly bright, and the minimum coinciding with the phase of greatest disturbance, which is also apparently that of greatest absorption of the photospheric radiation by the sun's atmosphere.

Journal of the Chemical Society, June 1887. Vol. LI. 8vo.

Contains :—A contribution to the study of Well Waters, by R. Warington, F.R.S. (52 pp.). This is a report of experiments made in the Rothamsted Laboratory. Among the chief facts brought out in this paper may be mentioned the following :—(1.) The proportion of chlorine in the rain at Rothamsted, average of 9 years, is 2 per million. At Cirencester, average of nearly 16 years, it is 3·25 per million. (2.) The proportion of ammonia in rain at Rothamsted, average of 5 years, is equal to 0·35 of nitrogen per million. The total combined nitrogen in the rain is apparently not more than 0·67 per million. (3.) The proportion of sulphuric acid in rain, calculated as sulphuric anhydride, average of 5 years, is 2·52 per million. (4.) At Rothamsted, with an average rainfall of 31 ins. during 16 years, 14 ins. have percolated through 5 feet of a bare clay soil containing flints, and 17 ins. have evaporated. The drainage is most active from October to February ; in these 5 months 9½ ins. have percolated, while in the remaining 7 months the percolation has been 4½ ins. (5.) When land is covered by vegetation, evaporation is increased ; summer drainage almost entirely ceases, and the main winter drainage commences in November rather than October. (6.) With a normally distributed rainfall the drainage season is from October to February, or with a smaller rainfall from November to February. The rise of the water level in the wells commences in January, and continues till March or April. The minimum contents of chlorides and nitrates in contaminated well waters are in October, the commencement of a rise in November. The maximum of chlorides is found in March or April, the maximum of nitrates in April.

Meteorologische Zeitschrift. Herausgegeben von der oesterreichischen Gesellschaft für Meteorologie und der deutschen meteorologischen Gesellschaft. Redigirt von Dr. J. Hann und Dr. W. Köppen. Vol. IV. Parts 4-6. April-June 1887. 4to.

Contains :—Untersuchungen über das Sättigungsdeficit, von Dr. H. Meyer (11 pp.). This is a defence of the author's views on the calculation of, and the importance of, the deficit of saturation as distinguished from the relative humidity. He describes a slide rule, and also a diagram for calculating this datum from the temperature and relative humidity, and he gives results for various instances of Föhn winds.—Phaenologie und Wetterprognose, von Dr. H. Hoffmann (3 pp.). This is a comparison of the dates of ripening of horse chestnuts, with the average temperature of the winter months at Giessen for the space of 36 years. The result is generally to the effect that fruit ripens early after a warm winter and late after a cold one.—Das Küstenklima der Provinz Pernambuco, von Prof. F. M. Draenert (7 pp.). This paper relates to the observations taken during seven or eight years at Pernambuco, Victoria and Colonia Isabel, all close together. The most interesting portions of the paper are the results as to weather rules, which offer a strong contrast to those observed in our own climate. The author points out that South and South-east winds are cold and produce high pressure ; they prevail in the wet season, but the North-east wind is warm and produces dry sunny weather. The land and sea breezes have no effect on the weather.—Resultate der Polarlicht-Beobachtung 1882-83, von Prof. H. Fritz (11 pp.). This is a discussion of the results at Jan Mayen, Fort Rae and Kingua Fjord.—Zum Klima von Korea, von Dr. A. Woeikof (5 pp.).—Weitere Berichte über Gewittererscheinungen im Schlesischen Gebirge, von Dr. Reimann

(14 pp.). This is an account of various peculiar phenomena in thunderstorms in the Riesengebirge, between Silesia and Bohemia. It appears that lightning striking upwards from a cloud is not uncommon at the stations at high levels.—Einiges über Wolkenformen, von Dr. W. Köppen (12 pp. and plate). This is a criticism of the attempts which have been made by Pocy and others to introduce a new classification of clouds, and winds up with long extracts from letters from Prof. Hildebrandsson in relation to the proposals made by him and Mr. Abercromby in this direction. Dr. Köppen strongly supports these proposals.—Die Einwirkung der barometrischen Minima und Maxima auf die Richtung des Wolkenzuges im Sommer- und Winterhalbjahr, von Dr. Vettin (9 pp. and plate). This is a continuation of Dr. Vettin's careful measurements of cloud motion at Berlin. He divides the year into summer and winter, and finds that the mean direction of all clouds is S 85°W in summer and W19°N in winter. The difference between the upper and lower currents is greater in summer than in winter, and greater with minima than with maxima.

PNEUMATICS, INCLUDING ACOUSTICS AND THE PHENOMENA OF WIND CURRENTS, for the use of Beginners. By CHARLES TOMLINSON, F.R.S., F.C.S. Fourth Edition enlarged. 8vo. 1887. 170 pp.

This book contains some useful information about the barometer and anemometer, and some good descriptions of several forms of instruments.

PROCEEDINGS OF THE AMERICAN ACADEMY OF ARTS AND SCIENCES. Vols. XXI.-XXII. 8vo. 1886.

Contains two papers on Thunderstorms, by W. M. Davis, viz.: (1.) On the methods of study of Thunderstorms (12 pp.). The author briefly describes the peculiar features of thunderstorms, and explains the methods adopted by the New England Meteorological Society for obtaining observations for the systematic study of thunderstorms. He also gives some notes on the methods employed in other countries for the same purpose.—(2.) Thunderstorms in New England in the summer of 1885 (45 pp). This is an interesting report on the observations made for the New England Meteorological Society.

PROCEEDINGS OF THE PHYSICAL SOCIETY OF LONDON. Vol. VIII. Part IV. April 1887. 8vo.

Contains:—On delicate Thermometers, by Prof. S. U. Pickering (5 pp.). The author says that it is a common practice of thermometer makers to examine the bore of a tube before it is made into a thermometer by passing a thread of mercury along it, and often, indeed, the stems are divided and fully calibrated before the bulb is attached and the tube closed. From what has been ascertained as to the effect of the air on the interior of the tube, it is obvious that a tube which has been treated in such a manner will be utterly useless for any really delicate instrument.—On the effect of pressure on Thermometer bulbs, and on some sources of error in Thermometers, by Prof. S. U. Pickering (7 pp.).

RENDICONTI DEL R. ISTITUTO LOMBARDO. Serie II. Vol. XX. fasc. V.-VI. 8vo. 1887.

Contains a note by Padre F. Denza on the inversion of temperature during January 1887 (7 pp.).

ROUSDON OBSERVATORY, DEVON. Vol. III. Meteorological Observations for the year 1886, made under the Superintendence of CUTHBERT E. PEEK, M.A., F.R.Met.Soc., F.R.A.S. 4to. 1887. 24 pp.

This Observatory is a Second Order Station of the Royal Meteorological Society, the monthly results being printed in the *Meteorological Record*. A series of observations on the depth and temperature of the water in an ancient well, 207 feet deep, were taken at intervals of fifteen days during the year. The mean depth of water was 5 ft. 7 in., and the mean temperature 51°·7, the extreme ranges being 1 ft. 11 ins. and 1°·9 respectively. Mr. Peek has also made some experiments on the evaporation from the surface of earth and from water. The apparatus consisted of two precisely similar iron tanks, 2 ft. square and 15 ins. deep, freely exposed to the air and protected from the rays of the sun by a louvred wooden frame. The tank containing the earth was placed on a weighing machine, the bottom being 2 ft. 6 ins. from the ground. The earth was ordinary soil, turfed over so as to represent meadow-land. At the bottom of the tank a tap was placed in order that surplus water might be drawn off and weighed. The water tank was at an equal height, and in all respects similar, except that an overflow pipe was placed so as to maintain the water at an uniform depth of 12 ins. The earth tank was weighed daily and the water tank measured on the first day of each month, a careful record being kept of the water added or drawn off in the interval, when necessary for maintaining the standard depth of 12 ins. The total evaporation from the earth tank for the year was 24·79 ins. and from the water tank 22·81 ins.

SYMONS'S MONTHLY METEOROLOGICAL MAGAZINE. Vol. XXII. Nos. 255-257. April-June 1887. 8vo.

The principal articles are:—Injury by Lightning (2 pp.).—The Snow of March 15th, 1887 (2 pp.).—Day and Night Breezes, by T. W. Backhouse (1 p).—Severe Winters and Vegetation (3 pp.).—Some new Weather Charts (2 pp.).—Redier's small Mercurial Barograph (2 pp.).—East Winds in Spring, by J. Paget (2 pp.).

THE JOURNAL OF THE ROYAL HORTICULTURAL SOCIETY. Vol. VIII. 8vo. 1887. lxv. + 888 pp.

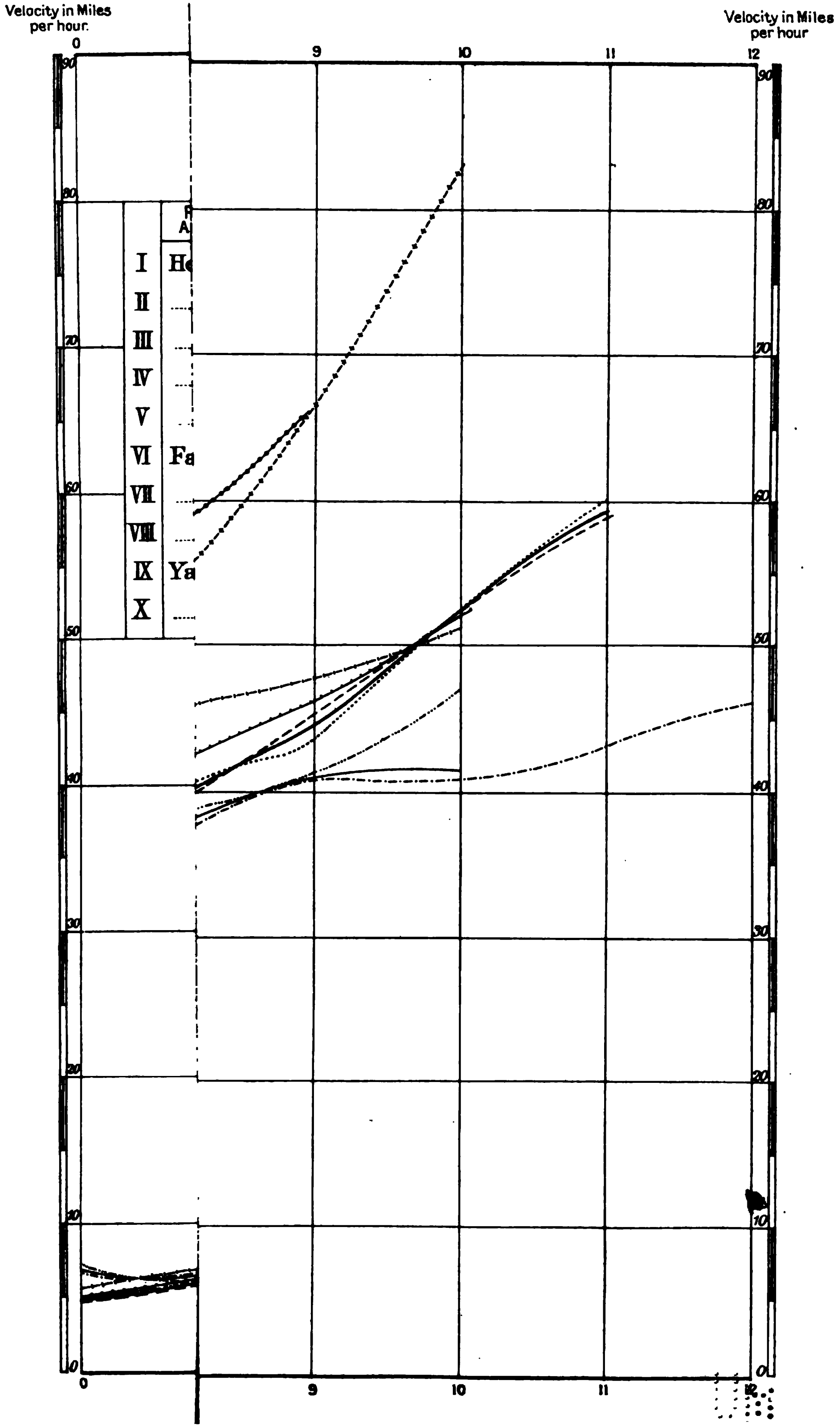
This volume is devoted to "The Frost Report," by the Rev. G. Henslow, who has made a detailed investigation into the effects of the severe frosts on vegetation during the winters 1879-80 and 1880-81.

THE SCOTTISH GEOGRAPHICAL MAGAZINE. Vol. III. Nos. 4-6. April-June 1887. 8vo.

Contains:—Rainfall in Australia, by J. T. Wills (13 pp. and 2 maps). The author gives two maps of Australian rainfall, and also some facts and considerations from which, under given climatic conditions, we may trace the limits of agriculture and estimate the pecuniary value of rain and irrigation water.—Cyclone in the Mozambique Channel, by H. E. O'Neill (4 pp. and plate). This gives some interesting extracts from the log of a vessel that passed through the vortex of a cyclone which moved down the African coast in the end of January 1887.

Quart: Journ: Roy: Met: Soc: Vol. XIII Pl. IV.

)RT'S SCALE.



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SESSION 1887-8.

ORDINARY MEETINGS AT 7 p.m.

WEDNESDAY,	NOVEMBER	16, 1887
,,	DECEMBER	21, ,,
,,	JANUARY*	18, 1888
,,	FEBRUARY	15, ,,
,,	MARCH	21, ,,
,,	APRIL	18, ,,
,,	MAY	16, ,,
,,	JUNE	20, ,,

* Annual General Meeting.

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QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY.

VOL. XIII. OCTOBER 1887. No. 64.

THE SO-CALLED "BROCKEN SPECTRES" AND THE BOWS THAT OFTEN ACCOMPANY THEM.

BY HENRY SHARPE.

(Communicated by G. J. SYMONS, F.R.S., Secretary.)

[Read May 18th, 1887.]

IN my inquiries into this subject I have made it a rule never to be satisfied with a translation, extract or copy, if I could by any means find the original. I shall make no statement that is not based upon the descriptions given in the Appendix, except as to pictures and glories. I believe that no such collection of descriptions has ever been made before; indeed, such could not have been made until lately, as more than half of the accounts were not in print four years ago. I have from time to time seen general statements and explanations of the phenomena by scientific writers. They do not say upon what descriptions they base their reasoning, and they often differ from one another, so I do not know what reliance is to be placed on their statements.

It is not necessary to go back to the old myths of tutelary spirits walking over the tops of the Harz mountains at sunrise. More than 100 years ago it was ascertained that these spirits were only shadows of the observers cast by the sun upon clouds, and from time to time descriptions of these gigantic shadows have been given by credible witnesses. The name "Brocken Spectre" has been given to the phenomenon. I shall use that name as it is commonly understood, and apply it only to shadows described as gigantic, or at any rate larger than life. In most descriptions from the Brocken the shadow is reported to have appeared alone. In many other descriptions the shadow is said to be surrounded by a bow, called by various writers, rainbow, fogbow, cloudbow, halo, prismatic halo, prismatic circle, fog circle, mirage, &c., all of which are more or less indefinite or incorrect. I propose to give it the name of the "Brocken Bow"—and shall show that it is like the rainbow in colour and in the order of the colours, and that its angular measurement is in many cases, if not in all, smaller than that of the rainbow.

The head of a shadow is sometimes surrounded by another sort of phenomenon touching the head, known by various names, of which the most appropriate seems to me to be "Glory." Glories vary very much in colour, size, and number of rings, and the inquiry into them would be very complicated. I have only found one description of a Glory with a gigantic shadow. The inquiry into them may be left to another time. I give a woodcut of a Brocken Bow (Fig. 1) as seen by myself, which, with a slight alteration of the size of the bow compared with the shadow, would do for a number of the other descriptions. I also give a woodcut of a Glory (Fig. 2).

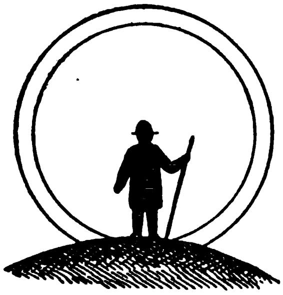

FIG. 1.—Brocken Bow.

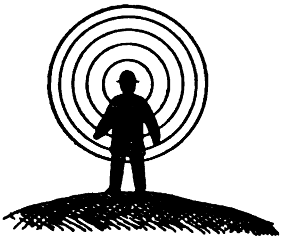

FIG. 2.—Glory.

There are two classes of people who consider this inquiry unnecessary: those who say that the gigantic size of the shadow is only due to the overheated imaginations and the extravagant language of observers; and those who say that there is nothing to explain, because the sun may cast a gigantic shadow just as well as a candle.

The earliest description that I have found is by Johann Esaias Silberschlag. The date of his book is 1780, but the description relates to some considerable time before that. He refers to an older description which I cannot find. He relates that he was on the Brocken—not on the top, but on the Heinrichshöhe, 866 feet lower, where there is an inn. He and others were watching the sunset. He turned to the east and saw shadows of the mountain, the inn and people on a gigantic scale upon the fog. There was no bow. Further particulars will be found (Ap. 1, p. 256). He stated the candle theory. The fog is like a wall, on which the shadows grow larger the further the object that produces the shadow is from the wall; the sun takes the place of the candle.

I am fortunate in having among my descriptions one by a gentleman so universally known and having such a character for accurate observation, as entirely to refute the suggestion of overheated imagination and extravagant language. Professor Tyndall's description will be found (Ap. 10, p. 258). This is the only case of a Brocken Spectre with a coloured fringe. What I saw (Ap. 12, p. 259), a Brocken Spectre and a Brocken Bow, is the most common variety of the phenomenon. Most of the descriptions do not give details enough, and many have slight inaccuracies, but these are not important, because the number of descriptions is so large. Considering the startling nature of the phenomenon and the short time that it usually lasts, I do not think any one is to blame for giving a description that is not quite complete and correct.

In Table I. are shown a number of particulars of all the Brocken Spectres. All were seen from mountains except the one from a steamer near the Lofoden Islands in the Arctic regions. All the mountains were over 2,000 feet in height, unless Ettrick and the Tryfan are lower. They occurred at all times of year, usually at sunrise or sunset. Rather more than half had bows. Only one (Ap. 19, p. 262) had a Glory, and that is rather doubtful, as the other observer described it as a rainbow. In several cases there were two bows. In one case (Ap. 27, p. 266) there was a halo of light and two bows. In another case (Ap. 24, p. 266) the observer describes a disc, but his companion says it was a bow. Mr. Sawyer describes (Ap. 16, p. 260) a horseshoe bow. The sizes and distances vary very much. Several observers state that the head of the shadow was in the centre of the bow, and only one (Ap. 14, p. 259) says the contrary.

In the Appendix besides Brocken Spectres I give separately descriptions of shadows not said to be larger than life, surrounded by Brocken Bows. Last of all I give Dr. McFait's shadow and double fringe, and Mr. Whymper's fogbow and crosses. I give this because I know it will be referred to. The bow was a white one, and Mr. Whymper says the crosses were not shadows, so it does not really belong here.

Putting aside the coloured fringe, and the horseshoe, and the glory, and the halo and disc of light, the two points to be inquired into are the gigantic size of the shadow and the bow. I will begin with the shadow. The candle theory is quite untenable. If we consider the sun to be a point, the shadow of a man will increase in size the further off it is from him. But as the sun is 92,700,000 miles from the man, the shadow will not increase one inch until it is more than a million of miles from the man. But the sun is not by any means a point. It is 850,000 miles in diameter, and its distance from us is only 109 times its diameter; consequently the rays from the two

TABLE I.—Brocken Spectres.

Apx.	Observer.	Year.	Place.	Time of Year.	Time of Day.	Surroundings.
1	Silberschlag	Before 1780	Brocken, Heinrichshöhe	14 days after Michaelmas	Sunset	
2	Goeze's Friend	1780	,,	August 30th	,,	
3	Ettrick Shepherd	About 1790	Ettrick	Summer	Sunrise	
4	Jordan	Before 1797	Brocken, top	After Whitsuntide	,,	
5	,,	,,	,, between top & Heinrichshöhe	,,	,,	
6	Haue	1797	,, Heinrichshöhe	May 23rd	,,	
7	French Savant		,,		Morning	
8	Menzies	1820	Ben Lomond	August 19th	Sunset	
9	Whaite	185–	Snowdon	Summer	Afternoon	2 Bows
10	Tyndall	1856	Furca		Sunset	Coloured outline or fringe
11	Stroobant	1862	Brocken, Heinrichshöhe	Summer	Sunrise	Bow
12	Sharpe	1862	Helvellyn	September	Near Sunset	,,
13	Gay	1868	Grand Som	September 3rd	5 p.m.	,,
14	Mathews	1873 or 4	Snowdon	December	Noon	,,
15	Baltzer	1875	Dossenhorn	September 7th	6 p.m.	,,
16	Sawyer	1877	Rigi	August	Sunrise	Horseshoe
17	Seton-Karr	1880	Piz Nair	July		Bow
18a	Barrett	1884	Glydr Vach	January	Noon	2 Ovoid bows
18b	Fleming	,,	,,	,,	,,	2 bows
19a	Morshead	1872?	Tryfan	April	Afternoon	Bow
19b	Kensington	,,	,,	,,		Glory
20	W. A. Greene	1878	Mikletveitveten	September 2nd	3 p.m.	Bow
21a	,,	1879	Gross Nesthorn	September 8th	8 a.m.	,,
21b	Rickman	,,	,,	,,	8.45 a.m. say	Oval bow
22	Wilson	1883	Scawfell Pike	Christmas Day		Elliptic bow
23a	Taylor	1884	Grisighorn	August	4 p.m.	2 bows
23b	Gotch	,,	,,	,,		
24a	White		Skye	Summer		Bow
24b	Brown		,,			Disc
25	White's Friend		,,		2 p.m.	Halo
26	Maynard		Piz Languard		Early Morn	Bow
27	Marr		Tonjabe Range			Halo of light and 2 bows
28	Firmstone		Mounts NE of Montreux	Midwinter		
29	,,		Niesen	August	Sunset	Bow
30	Coleman	1881	Lofoden Islands		Sun rather low	,,

TABLE I.—BROCKEN SPECTRES (*Continued.*)

Apx.	Size.	Distance.	If Shadows of others seen.	Details seen.	Duration.
1	Colossal		Yes, and house	Feet, arms, handkerchief	From when the sun touched the horizon to when it set
2	Similar to Silberschlag's				
3	30 feet	Very near	Dogs	Fingers, nose	
4	Gigantic				As soon as I saw it, it began to disappear
5	Tremendous			Movements	A few seconds
6	500 or 600 feet	4⅔ miles	Yes	Arms, hat	
7			Yes		
8	Gigantic	2½ miles	Yes	Arms, hat, umbrella	A quarter of an hour
9	Considerably enlarged		Yes		
10	Colossal		Yes	Arms, alpenstock	
11	Gigantic		Yes, inn	In a more vague and less exact shape	Some instants
12	30 or 60 feet	100 or 200 yards		Legs, arms, alpenstock	A quarter of an hour or more
13	A little enlarged		Yes, cross		
14	Gigantic	300 or 400 yards	Yes		3 or 4 minutes on and off
15	Parts moved gigantic		When moving	Arms and legs	
16	10 feet	100 to 150 feet	Yes	Hat, umbrella and guide book	
17	Brocken		No		
18a	Rather larger than life		Yes	Arms	Several minutes on and off
18b	Immense		Yes	,,	A few minutes
19a	Not much larger than life		Yes		Some time
19b	,, ,,		Yes		
20	Considerably larger than life		No		
21a	,, ,,		No		
21b	Life size	50 to 25 yards	No		
22	Gigantic	¼ mile	Yes	Actions	
23a	A little larger than life?		Yes		Some time
23b	Life size and then gigantic				
24a	Similar to Fleming	200 feet or more	Yes, if close		
24b			,, ,,		
25	Brocken	60 to 100 yards			
26	Same as Fleming		Yes	Wave hat, vivid	Longer than Fleming
27	Monstrous	A short distance		Head	
28	Gigantic	A long way off	Yes		Very transitory
29	Weird and awful		Yes		
30	Enlarged	Within a few yards	No	Head	A few minutes

edges of the sun passing by the two sides of a man's body will meet at a point beyond the man distant from him 109 times the width of his body. Take the width of his body without his arms as 16 inches, the rays will meet at 145 feet 4 inches, say 48 yards. At that distance there will be no real shadow, but a penumbra, twice as wide as his body, and dying gradually off to nothing at the sides. At any distance short of 48 yards there will be a narrow shadow and a penumbra, the shadow growing wider and the penumbra narrower as they are closer to the man. At half the distance the shadow will be 8 inches wide with a penumbra of 8 inches on each side. Beyond 48 yards the penumbra will be broader and not so dark, growing more and more indistinct the further off it is. As the outline of a man's figure is very irregular, the outline of the penumbra which is caused by rays from different parts of the sun does not correspond with it. I am looking at this in a mathematical way only, I do not go into the question of diffraction.

I have made experiments with my shadow on the ground at different distances. I find that there is no line between the shadow and the penumbra, and that it is impossible to say exactly where the one ends and the other begins. Also it is impossible to say exactly where the penumbra ends. The shadow, even at a few feet, has not a sharp edge like a shadow from a candle. At 60 yards my shadow was a shapeless lump, not to be distinguished as the shadow of a man. I could only see the shadows of my arms when I moved them. At 35 yards arms and legs were barely visible. At 18 yards my Alpenstock was very broad and indistinct. At 6 yards my fingers extended could not be counted; at 5 yards they were distinct. A good shadow of a man, showing his arms and legs distinctly, and of the right thickness, is not formed beyond 17 yards, and a good shadow of an Alpenstock is not formed beyond 8 yards. These distances may vary a little with the brightness of the sun and the ground upon which the shadow falls, but I do not think they will vary much.

All pictures of men and their Brocken Spectres are imaginary. Two men may see one another's Brocken Spectres if they stand close together, but, as far as I can ascertain, no man has ever seen another man and his Brocken Spectre at sufficient distance to be able to draw them. I shall go through the pictures that I have seen. Silberschlag's description (Ap. 1, p. 256) has no picture. Dr. Lommel quotes it in *Wind und Wetter*, Munich, 1878, and puts in a picture. Professor Prestel quotes from him in the *Illustrirte Zeitung*, Leipzig, 1877, No. 1750, and copies the picture. Mr. Tomlinson, in his description by the Ettrick Shepherd, gives a picture of the Shepherd and his Brocken Spectre. No one was there to draw them. Mr. Tomlinson tells me that the picture was made by his orders. M. Flammarion, in his description of M. Stroobant (Ap. 11, p. 258), gives a drawing by that gentleman of *himself* and his guide in the distance with their Brocken Spectres. There is no bow in the picture, though there is one in the description. I have seen the same picture in a cutting from a German newspaper, with a bow. Haue's description was written in the visitor's book of the inn on the Brocken. Jordan printed it (Ap. 6, p. 258) without a picture. It is almost certain that all subsequent quotations are from Jordan. Dr. Hartwig quotes and inserts a picture, *Aerial World*, p. 209, London, 1874. Dr. Brewster, in his *Letters on Natural Magic*, London, 1842, p. 127, quotes and inserts a picture of two men and three Brocken Spectres. The third shadow is owing to a mistake in the translation. Milner, in his description (Ap. 7, p. 258) of the French *savant* and his guide, gives a picture of two men and their Brocken Spectres. He does not mention that any one else was there to draw them.

Having shown that a shadow (not a penumbra) larger than life is impossible, and that a good shadow can not be formed at many of the distances named, it remains for me to state how I account for the gigantic size described by so many people. I consider that it is due to a mistake in judging the distance. The observer thinks that his shadow is a long way off and gigantic, when it really is closer to him and life-size. In many cases each observer saw only his own shadow, and not that of his companions. A shadow on a fog is not like a shadow on a wall. Part of the shadow falls on drops at one distance from the man and other parts on drops at other distances. Consequently, the shadow can only be seen by some one looking at it from nearly the same direction as the man whose shadow it is. If the shadow was really at a great distance, there would not be much difficulty in the second man seeing it, if standing at a short distance from the man causing the shadow. If the nearest part of the shadow is within a few feet of the man, the other man would have to be very close indeed to see it. Mr. White and Mr. Brown (Ap. 24, a and b, p. 264) made a very interesting experiment. Mr. Brown says:—"So long as we kept a few yards apart each could only see his own shadow, but when two were within arm's length a double shadow was visible to each." Mr. White estimated the distance of the shadows at 200 feet or more. It is certain that, if the shadows had been at that distance, each man would have seen the other's shadow when they were further apart than arm's length.

In descriptions (Ap. 31 to 37½, p. 267) of shadows with Brocken Bows it is not stated that the shadows were larger than life. The Rev. F. T. Weatherhead (Ap. 34, p. 268) describes the bow as 2 or 3 yards in diameter. If the shadow had reached from the centre to the bottom of the bow, it could only have been 3 or 4½ feet high. From his description I should say that it did not reach nearly so far, so that it must have appeared smaller than that. He must have underestimated the distance.

In five cases I have been able to get two descriptions of the same Brocken Spectre. In one (Ap. 24, p. 264) only one observer mentions the size. In another (Ap. 19, p. 262) the two descriptions of size are not independent. In three cases they are independent. In (Ap. 18, p. 261) one observer says rather larger than life, the other says immense. In (Ap. 21, p. 262) one says considerably larger than life, the other says life-size. (In Ap. 23, p. 263) one says he thinks a little larger than life, the other says life-size and afterwards gigantic.

I have mentioned that in one of my experiments I could only see the shadows of my arms when I moved them. This shows that a shadow, too slight to be seen when still, may be seen when moving. This is confirmed by Dr. Baltzer (Ap. 15 p. 260), who says that he could not see his guide's shadow unless the guide moved. He also says that although his shadow appeared to be life-size, when he moved arms or legs they appeared gigantic. My explanation is this. When he moved arms or legs, he saw the shadow of them on some mist nearer than that on which he saw the rest of the shadow, and that this shadow had been too slight to notice when arms and legs were at rest. This shadow being nearer appeared gigantic. I have seen the same thing described by M. A. Tissandier (*L'Océan Aérien*, par Gaston Tissandier, Paris 1884, p. 217), in a case of shadow and glories, who says that when he moved his arms there were dark rays like the sails of a windmill moving beyond them. Mr. Marr (Ap. 27, p. 266) mentions rays of colour normal to the body shooting out, but he does not say that they had anything to do with his arms. The Hon. Ralph Abercromby, (Ap. 37, p. 269) saw dark rays: he says that they had nothing to do with his arms, and were nearly in continuation of the sloping sides of the mountain.

I would suggest the following experiments to future observers, if two are together. Let each judge the height and distance of the shadows, and write them down before speaking to his companion. Then let one stand still and the other go a little distance towards the sun and see whether the shadow of the one who stands motionless still appears gigantic. It probably will not. Then let him go back and move right or left to see at what distance they can see one another's shadows and at what distance they cannot.

After I had hit upon the explanation of the apparently gigantic size of the shadow, I found that the same explanation had been given by Professor Eugene Lommel in *Wind und Wetter*, Munich, 1873, p. 317. He does not give it as if it was a discovery of his own. Professor Prestel quotes him in the *Illustrirte Zeitung*, Leipzig, 1877, No. 1750. Professor Albert Heim makes the same statement in the *Jahrbuch* of the Swiss Alpine Club, Vol. XIV., Berne, 1878-9, p. 406. The first two do not appear to have seen Brocken Spectres, and give no reasons for their opinions. The third says that he has seen shadows that appeared gigantic all over, but that they disappeared almost immediately, and considers the mistake due to the eyes being startled. The statements of these gentlemen do not appear to be known here, and from their offering no proof of the impossibility of the gigantic size, I do not think that their statements would be accepted by any one who had seen a really good Brocken Spectre. I have corresponded with 19 gentlemen who have seen Brocken Spectres, including Professor Tyndall and Professor Huxley, and none of them express any doubt about the shadows being really the size that they appear to be, except Mr. Gotch (Ap. 28b, p. 268). Dr. Baltzer (Ap. 15, p. 260) has read Professor Heim's paper and appears to accept his conclusions.

I now come to the question of Brocken Bows. In Table II. I give a list of these bows with Brocken Spectres and with other shadows.

In many cases they are described as rainbows, or of the colours of the

TABLE II.—Brocken Bows.

With Brocken Spectres.

Apx.	Observer.	Diam.	Description.	Outer Bow.
9	Whaite		Two rainbows	Reversed order
11	Stroobant		Arc-en-ciel	
12	Sharpe	11°	Rainbow, not very bright	
13	Gay		Cercle irisé . . présentant toutes les couleurs du spectre, le violet à l'interieur, le rouge au dehors	
14	Mathews		Circular bow. Fog bow	
15	Baltzer		Ein ganzer Kreis in grellen Regenbogenfarben	
17	Seton-Karr		Circle of prismatic colours	
18a	Barrett		Circular rainbow, complete. Ovoid. Colours of inner rainbow very bright and in order of primary bow	Secondary fainter.
18b	Fleming	20°	Two concentric rainbows completely circular. The colours of the inner one in the order of the primary bow	Secondary, more faintly tinted rainbow
19a	Morshead		Complete circular rainbow	
20	W. A Greene		Circular rainbow hardly so bright as Barrett	
21a	„		„ „ „	
21b	Rickman		Fog bow, a slightly luminous oval, on the outside of which are the colours of the rainbow	
22	Wilson		Complete halo of the colours of the rainbow, elliptical in form	
23a	Taylor		Rainbow with colours fully developed, red external, violet internal	Secondary
24a	White	15°	Rainbow	
24b	Brown	10°	Circular disc of light ?	
25	White's friend	8°		
26	Maynard		Circular rainbow	
27	Marr		Two circles of rainbow light and colour, inner bright	Faintly defined
29	Firmstone		Circle of rainbow hues	
30	Coleman		Brightly coloured halo or rainbow	

With other Shadows.

Apx.	Observer.	Diam.	Description.	Outer Bow.
31	McFait		Rainbow	Usual outer bow in fainter colours
32	Sykes		Circular rainbow, most vivid colours	
33	Goret		Cercle aux couleurs de l'arc-en-ciel	
34	Weatherhead	10° or 14½°	Fog bow, perfectly defined circle, composed of clearly coloured and concentric rings	
35	Maude		Prismatic halo, circular	
36	Wueste		Double rainbow	Outer bow
37	Abercromby	8°	Complete prismatic circle, red outside. Bow. Rainbow	Outer bow, fainter

rainbow. In no case are they described as of any other colours, or having the colours in any other order than the rainbow. The Hon. Ralph Abercromby (Ap. 87, p. 269) says that when the bow was very faint, the violet and part of the blue could not be seen. That, I believe, may happen with a rainbow.

In two cases (Ap. 18 and 21, p. 261) one observer thought the bow circular, and the other ovoid or oval. In one case (Ap. 22, p. 268) all the observers thought it elliptical. I believe this only comes from looking at it in different ways. The mathematician says that all bows are to be looked at as if in a plane at right angles to a line from the eye to the centre of the bow. Then they will all look circular. The artist says that all rainbows are to be looked at as if in a plane perpendicular to the horizon. Then no rainbows will look circular except at sunset or sunrise. It is the same with Brocken Bows. Those described as not circular were not seen at sunset or sunrise.

In eight cases there was an outer bow. In four of these it is stated to have been fainter than the inner bow. In three cases it is called a secondary. In one case it is called the usual outer bow. In one case it is stated positively that the colours were in reversed order. In some cases it did not last so long as the outer bow. In no case did it last longer.

Seven estimates of the angular size, or of the distance and diameter in feet or yards, are given. The angles vary from 8° to 20°. Many of the other descriptions seem to describe a bow smaller than a rainbow.

No mention is made of the width of the colours. From my own recollection and from studying the descriptions, I should say that it is probably not so broad as in a rainbow. Possibly it varies.

In Table III. I have given extracts from the descriptions about the state of the atmosphere. I did this principally in order to ascertain whether there was usually any mist between the observer and the sun. The table shows decidedly that there is not. This is an important point, and one of the great differences between Brocken Bows and Glories. The temperature is only mentioned in one case. The Hon. Ralph Abercromby (Ap. 37, p. 269) gives it as 52° about half an hour before the appearance of the phenomenon. From a study of the descriptions, I do not think that there can have been frost in as many as six cases when there were Brocken Bows. This shows that it is of no use seeking a theory based upon the supposition that the mist consists of frozen particles.

The points to which future observers should direct their attention are the colours of the bows, the diameters of the bows, and the width of the colours. Mountain climbers seldom carry instruments, and the measurements can be made just as well without them. Shut one eye; hold up your pocket handkerchief at arm's length; with one hand hold one corner to cover one side of the bow: hold the handkerchief straight across the bow, with the thumb and finger of the other hand holding it at the place that covers the other side of the bow; there tie a knot; hold it up again to see that the knot is in the right place, and the observation is made. When you reach a civilised place, measure the distance on the handkerchief, and from the handkerchief halfway between your hands to your eye. From these measurements the angle may easily be calculated. A mistake of half an inch will only make a difference of about a degree. The measurement of the width of the colours is not so easy, because it is probably under an inch. I think it might be done by holding up something small, a pencil or knife, in one hand, and marking the width with your thumb. The object in measuring the bows is

TABLE III.—State of the Atmosphere.

Brocken Spectres without Bows.

Apx.	Observer.	Towards Sun.	Where Observer stood.	From Sun.
1	Silberschlag			Dünne Nebel
4	Jordan			Dicke Nebel
6	Haue	Luft rein, die Sonne könnte also ungehindert ihre Strahlen werfen		
10	Tyndall			Wall of fog
28	Firmstone	Sickly gleams of sunshine filtered through the fog		
			Brocken Spectres with Bows.	
11	Stroobant			Un brouillard épais qui semblait sortir des nuages comme un immense rideau
12	Sharpe	Bright sunshine	Quite clear of the mist	Mist blown up from below
13	Gay		Des nuages nous envelopaient à tout instant	
15	Baltzer			Eine ungeheure Nebelwand
17	Seton-Karr		I was in the edge or border of a cloud	
18	Barrett	The sun burst forth with brilliant rays		Thin cloud and scud driving before the wind
18a	Fleming	The sun was shining brightly at our backs		The wind drove masses of thin mist or scud
22	Wilson	The sun was shining brightly at our backs		Clouds rolled up from the rocks beneath
23a	Taylor			Thin clouds of mist curling about like vapour from a large cauldron
26	Maynard	Unclouded sun		The whole abyss presented the appearance of a seething cauldron, from which was escaping a cloud of steam
29	Firmstone	The sky remained clear as before		
			Other Shadows with Bows.	
31	McFait		The air at this time very clear and agreeable to breathe in	The country seemed buried under a vast deluge
32	Sykes	A cloudless sun at my back	Just without the limits of the fog	
33	Goret	C'était serein en Suisse		Le nuage était très dense
34	Weatherhead	There was no apparent sunlight		
35	Maude	The sun was shining brightly	We were just above the clouds	A white mass which obscured all view

not to find out their exact size, but to find out for certain whether they are smaller than the rainbow, and whether they vary in size. A drawing should be made.

Another point to be ascertained is the distance of the bow from the observer. Several descriptions make the shadow surrounded by a complete circular bow. I leave out of the question the shadow of the legs, and I take a man as 5 ft. 8 ins. up to the eyes. A bow of any angle may be a complete circle if it is not more than 10 ft. 6 ins. diameter. If larger, the bottom would be destroyed by the shadow of the ground on which the man stands. A rainbow, to be a complete circle, would have to be within 5 ft. 10 ins. of the man. Any bow that appears to go below the feet of the shadow must be nearer than the shadow. To measure the distance of the bow, first measure its angular size. If the bow is a complete circle, stoop till the bottom is destroyed by the shadow of the ground. Measure the height to the eye with the help of an alpenstock. From this height and the angle the distance may be calculated. If the bow is not a complete circle, make a drawing of it, and having found how many degrees it is in diameter, it is possible to find out how many degrees the lowest part of the bow that is visible is below the centre. The centre is 5 ft. 8. ins. above the shadow of the ground. From this the distance may be calculated. But it can only be done if the ground is level to the right and left of the observer.

I have shown that, as far as I can ascertain, the Brocken Bow is like the rainbow in everything except its angular size, and that it varies in size; also that there is no mist between the observer and the sun, and that the temperature when the bow is seen is usually if not always above freezing point.

I have seen it stated more than once that the theory of this bow is known, and that it is due to diffraction or something of that sort; I have inquired for this theory, but have not been able to find it. I do not believe that any such theory has ever been calculated out. I doubt whether any one has ever had the data from which to calculate.

I hope that some mathematician will attempt to find out the theory from the data that I give. If he can do this he may show in what state water is suspended in mist or cloud.

APPENDIX.

BROCKEN SPECTRES.

(1.) *Geogenie, oder Erklärung der Mosaischen Erdbeschaffung, &c.* JOHANN ESAIAS SILBERSCHLAG. Berlin, 1780-3.

VOL. I. p. 139 (translation). The first time that I was on this mountain (the Brocken) the visitors went out in the evening to see the beautiful sunset. It was about a fortnight after Michaelmas, a time when the autumn fogs rise. Just as the sun's disc touched the horizon, I turned to the east, and suddenly I saw, in the direction of Halberstadt, the shadow of the mountain much larger than the mountain itself. Everything was shown so distinctly on the fog, that we could see the house and the people near it. This enormous spectre looked more dreadful because it seemed to come out of the darkness of night which already covered the lower country. The outline was tinged with the red of evening. It imitated all the movements of the people who moved about on the top of the mountain, each like an enormous cyclops. The little house on the Brocken looked like a palace, our feet like twisted pine trees, and our arms like masts. A pocket handkerchief represented a sail. It is easy to explain this phenomenon. The thin fog represents a wall, on which the shadows grow larger the further the object causing the shadow is from the wall. The sun takes the place of a candle.

(2.) *Jahrbücher des Brockens*, 1753 bis 1790. Schröder. Magdeburg 1791. [This is the visitor's book of the inn on the Brocken.]

P. 192 (translation). 1780, 30th and 31st August. JOHANN EPHRAIM GOEZE. Saw a beautiful sunset. Some of my friends saw on a fog in the east the Brocken Spectre described by Silberschlag.

(3.) *The Dew-drop and the Mist, &c.* By Charles Tomlinson (? 1860).

P. 337. The ETTRICK SHEPHERD has described in his droll manner a remarkable appearance which he witnessed among the mountains of Scotland. In warm summer mornings the valleys are filled with a dense white fog, "so that when the sun rises, the upper parts of the hills are all bathed in yellow sheen, looking like golden islands in a sea of silver. After one ascends through the mist to within a certain distance of the sunshine, a halo of glory is thrown round his head, something like a rainbow, but brighter and paler." On one occasion, as the shepherd was ascending a hill-side deeply absorbed in admiration of the halo around him, his eyes fell suddenly upon a huge dark semblance of a human form standing not very far off. Being very much alarmed, he rushed from the spot and rested not till he had got safe among the ewe milkers. Having to pass the same spot at the same hour on the next morning, he resolved, if possible, to exert a little more courage, and put the appearance fairly to the proof. "The fog was more dense than on the preceding morning, and when the sun rose his brilliancy and fervour were more bright above. The lovely halo was thrown around me, and at length I reached the haunted spot, without diverging a step from my usual little footpath; and at the very place there arose the same terrible apparition which had frightened me so much the morning before. It was a giant blackamore, at least 30 feet high, and equally proportioned, and very near me." Being much alarmed, the first impulse of the shepherd was to run home and hide himself; but thinking of his master's 700 ewes, he paused, and in his perplexity took off his cap and scratched his head with both hands, when, to his astonishment and delight, the figure also took off his cap and scratched his head with both hands, "but in such style; oh, there's no man can describe it! His arms and fingers were like trees and branches without leaves. I laughed at him till I actually fell down upon the sward; the figure also fell down and laughed at me. I then noted for the first time that he had two colley dogs at his feet, bigger than buffaloes. I arose, and made him a most graceful bow, which he returned at the same moment—but such a bow for awkwardness I never saw! It was as if Tron Kirk steeple had bowed to me. I turned my cheek to the sun as well as I could, that I might see the figure's profile properly defined in the cloud; it was capital! His nose was about half a yard long, his face at least three yards; and then he was gaping and laughing so that one would have thought he might have swallowed the biggest man in the country. It was quite a scene of enchantment. I could not leave it. On going five or six steps onward, it vanished; but on returning to the same spot, there he stood, and I could make him make a fool of himself as much as I liked; but always as the sun rose higher he grew shorter, so that I think, could I have stayed, he might have come to a respectable size at last." The shepherd states that he saw this gigantic shadow several times since, but not half so well defined as on the morning above referred to. It was only seen during a fog, and at sunrising.

[The Ettrick Shepherd was James Hogg, the poet, born 1772. Mr. Tomlinson is not able to tell me from what book he took this description.]

(4 and 5.) Gmelin (J. M.). *Göttingisches Journal der Naturwissenschaften.* Göttingen 1798.

Vol. I. part iii. p. 100. Beobachtung des Brockengespenstes mitgetheilt von J. LUD. JORDAN (abbreviated). He relates that he had twice seen gigantic shadows of himself from the Brocken at sunrise, lasting a very short time, both times after Whitsuntide.

(6.) He also extracted from the visitor's book of the inn on the Brocken a description by Haue of gigantic shadows that he saw 23rd May 1797. He had made thirty ascents in order to see the phenomenon. From a mis-translation of a passage in this description, Sir D. Brewster says there were two men and three shadows. The passage is "Der 3te Mann kam dazu." He had not before used the word "Mann" for "shadow," and it is clear from the context that that is not his meaning. He expresses no surprise. It can only mean, "A third man joined us." There were two before, himself and the innkeeper. Haue says the shadows are 500 or 600 feet high, and 4⅔ miles off.

(7.) *The Gallery of Nature*, by Rev. Thomas Milner, M.A., F.R.G.S. London and Edinburgh, 1860.

P. 541. A French Savant, attended by a friend, went to the Brocken to watch this spectral shape, but for many mornings they traversed the opposite ridge in vain. At length, however, it was discovered, having also a companion, and both figures were found imitating all the motions of the philosopher and his friend.

(8.) Ditto.

P. 541 (abbreviation). On 19th August, 1820, Mr. Menzies, a surgeon of Glasgow, and Mr. Macgregor reached the top of Ben Lomond at about half-past seven, just before sunset. There was a cloud in the east, apparently at a distance of two miles and a half, on which they saw two gigantic figures on a pedestal. The appearance continued for about a quarter of an hour. The weather was fine, but there had been a shower on the way up.

(9.) Mr. W. Clarence Whaite, of 16 Douro Place, Victoria Road, Kensington, has given me a verbal description.

One afternoon in the summer of 185— he was on the top of Snowdon with some friends. Standing on the cairn with them he saw the shadows of the top of the mountain and of the party considerably enlarged upon a cloud that was not far off. Round the shadows were two rainbows, the outer one having the colours in reversed order as usual. The shadow of his head was in the centre. The bottoms of the rainbows were cut off by the shadow of the mountain, and they were not so nearly complete as the bow that I saw. He is an artist, and has studied rainbows, and has often painted them. He had always considered that the bows above described were rainbows, but upon my telling him that bows upon clouds were often smaller in angular measurement than rainbows, he said that perhaps what he saw might have been rather smaller.

(10.) *The Glaciers of the Alps*, by John Tyndall, F.R.S. London, John Murray, 1860.

P. 22, 1856. The sun was sloping to the west....As the sun sank, the shadow of the Finster Aar Horn was cast through the adjacent atmosphere....Proceeding along the mountain to the Furca, we found the valley at the further side of the pass also filled with fog, which rose like a wall, high above the region of actual shadow. Once, on turning a corner, an exclamation of surprise burst simultaneously from my companion (Professor Huxley) and myself. Before each of us, and against the wall of fog, stood a spectral image of a man of colossal dimensions; dark as a whole, but bounded by a coloured outline. We stretched forth our arms, the spectres did the same. We raised our alpenstocks; the spectres flourished their batons. All our actions were imitated by the fringed and gigantic shades. We had in fact the spirit of the Brocken before us in perfection. P. 238, Professor Tyndall speaks of coloured fringe.

I wrote to Professor Huxley, asking him for an independent description. His answer was:—I regret that I can add nothing to what Prof. Tyndall has said about the appearance to which you refer. I made no notes on the subject at the time.

(11.) *L'Atmosphère, Description des Grands Phénomènes de la Nature*, par Camille Flammarion. Paris, 1872.

P. 200. Il y a quelques années (été de 1862) un artist français, M. Stroobant, a pu observer et dessiner avec soin ce phénomène. C'est ce dessin que l'on voit ici. L'observateur était allé coucher à l'auberge du Brocken, et s'étant fait éveiller vers deux heurs du matin, il parcourrut le sommet du plateau en compagnie d'un guide. Ils arrivérent au bord d'un point culminant au moment où les premiers lueurs du soleil levant permettaient de distinguer avec netteté les objets qui se trouvaient à une assez grande distance. " Mon guide, dit M. Stroobant, qui depuis quelque temps marchait le nez au vent, regardant tantôt à la droit, tantôt à la gauche, m'entraina tout à coup sur une élévation d'où j'eus le rare bonheur de contempler pendant quelques instants ce magnifique effet de mirage qu'on appelle le Spectre du Brocken. L'effet en est saisissant ; un brouillard épais qui semblait sortir des nuages comme un immense rideau, s'éleva tout à coup à l'ouest de la montaigne ; un arc-en-ciel se forma, puis certains formes indécises se dessinèrent. C'était d'abord le grand tour de l'auberge qui s'y trouvait reproduite dans des proportions gigantesques, puis nos deux silhouettes plus vagues et moins correctes ; toutes ses ombres portées étaient entourées des couleurs de l'arc-en-ciel servant de cadre à ce tableau féerique. Quelques touristes qui se trouvaient à l'hotel avaient vu, de leur fenêtre, apparaitre l'astre à l'horizon, mais personne n'avait apperçu la grande scène qui se passait de l'autre côté de la montaigne.

(12.) HENRY SHARPE, 44 Well Walk, Hampstead.

On 27th Sept. 1862 I went up Helvellyn alone in the afternoon. The following notes were written on the spot:—

" Helvellyn, 4.30 p.m., strong wind, clouds white, heavy but broken, sunshine between; top clear two or three times before I got there, distance dim, average height of bottom of clouds 2,500, 3,000 (no, lower). Cold, tops of Bowfell and others caught sight of every few minutes, dead black, clouds quite white. 5 p.m. much clearer. Skiddaw and Saddleback never clear, clouds light, sky over Skiddaw green, clouds slightly coloured, Bowfell dark purple, Skiddaw light purple. 4.30 p.m. (*sic*) some mountains green, purple and black. Opposite sun saw circular rainbow about 100 or 200 yards off, and myself standing in the middle as large as if 20 yards off (here came a small sketch). 5.30 p.m. Bowfell, &c. dead purple and black, with bright light clouds in between; Yorkshire hills seen. 6 p.m., mackerel clouds in west tinged red, south pink and white, north low, greenish stone colour, some clouds still pure white. A little later clouds north almost green, south-west high, yellow, and low misty. All the time misty in valleys towards sun."

To these notes I will add that it was such an extraordinary day that I stopped at the top for an hour-and-a-half in a piercing wind. The second 4.30 p.m. appears to be a mistake, so that the time when I saw the phenomenon is doubtful. When I saw it I was standing in bright sunshine, quite clear of the mist, which was being blown wildly up the eastern precipitous side. The bow was a complete circle, except a small part at the bottom, where the shadow of the mountain came. The head of the shadow was in the centre of the bow, and the feet would nearly have touched the bottom if it had been complete. The bow was like a rainbow in colour and in the order of the colours, but it was rather faint; I could see the shadow of my alpenstock. The shadow and bow appeared to be at the same distance. The shadow is said to have looked as large as if it had been at 20 yards. 6 feet at 20 yards measures 6°. This would make the diameter of the bow 12°, but this must not be considered exact.

(13.) *Comptes Rendus, &c., de l'Académie des Sciences.* Vol. LXXV. Paris, 1872.

P. 161, Météorologie. . . . Note de M. J. GAY. . . . Le 3 Septembre, 1868, vers 5 heures du soir, je me trouvais, avec plusieures personnes, sur l'étroite plate-forme qui termine le Grand-Som (2,033 mètres d'altitude), et dont les parois se dressent à pic audessus de la Grande-Chartreuse. Des nuages nous envelopaient à chaque instant ; le Soleil près de se coucher, projeta notre ombre et celle de la croix plantée sur le sommet, un peu agrandies et entourées d'un cercle irisé. Nous pouvions voir distinctement nos mouvements reproduits par l'ombre ; elle paraissait être à une centaine de pas et un peu au-dessous de nous : un cercle présentant toutes les couleurs du spectre, le violet à l'intérieur, le rouge au dehors, l'entourant completement.

(14.) Extracts from Letters to me from Mr. CHARLES EDWARD MATHEWS, of Edgbaston, Birmingham, President of the Alpine Club, 10th and 13th December, 1886, and 7th February, 1887.

One day in December, twelve or thirteen years ago, I was standing with the late

Mr. Adams-Reilly upon the cairn at Snowdon, sun south, clouds north. Our shadows were gigantic and appeared outside the fog bow. The bottom of the fog bow was not complete, otherwise it was a circle. We were engaged eating sandwiches, and as we danced on the top of the cairn, so did our gigantic figures outside the bow. Our figures appeared and reappeared as the clouds drifted—a splendid apparition lasting 3 or 4 minutes. I cannot recollect how far the distance was, probably three or four hundred yards from the top of the cairn. I have never spoken to anyone who has seen a similar spectre. A few days after the Snowdon adventure we had a precisely similar spectre on Cader Idris, but not nearly so complete or good.

(15.) *Jahrbuch des Schweizer Alpenclub*. Vol. XI. Berne.

P. 546 (translation). *Brocken Spectre*. By Dr. A. BALTZER. On the top of the Dossenhorn (3,140 metres) I saw, on the 7th September, 1875, the phenomenon usually called the Brocken spectre. The sun was in the west, and in the east was a tremendous wall of fog. We were between the two. On this wall appeared, first a half circle, and then a whole circle of bright rainbow colours. The apparent diameter was 20 to 30 feet. In the ring was our shadow. But each of us only saw his own shadow, although we were standing close together. I could sometimes see the shadow of my guide very faintly when he moved and I stood still. When I moved arms or legs the shadow moved its arms or legs, and they grew to a gigantic size which was very comical. When we moved on, the legend of the seven league boots appeared to be true.

(16.) An Old Boy's Natural History Reminiscences. A Lecture delivered at the Brighton Grammar School, April 9th, 1886, by FREDERICK E. SAWYER, F.S.A., F.R.Met.Soc., &c., reprinted from the *School Magazine*.

P. 8. In August 1877 I visited Switzerland for the first time, and ascended the Rigi. I arrived about 1 p.m., and soon after "the clouds descended and the rains beat against the house," and the thunder could be heard 1,000 to 2,000 feet below. Early next morning I was awakened by the loud blowing of a cow's horn. I turned out about 4.30 a.m., as the foreigners beautifully put it "to assist" at the rising of the sun. There was a dense mist, and nothing could be seen at a greater distance than two feet off. The sun had risen but was invisible, and many returned in disgust to the hotel. I lingered about, and presently found the sky clearing, and at one instant when the sun was visible for a moment I observed the shadow of myself and some Germans standing near suddenly projected on the mist below, as in a magic lantern view, and surrounded by a large halo in the shape of a horse shoe, the whole being in prismatic colours as in a rainbow. This was the "Rigi Spectre," which is well known, though not so celebrated as "the Brocken Spectre," of North Germany. I waited half-an-hour to see if the same conditions would arise again, viz. the sky clear between myself and the sun, but the mist still continuing, I was then fortunate enough to see *my own spectre*, and to render it certain I raised my umbrella above my head, and there was my glorified spectre surrounded with a rainbow nimbus, like the pictures of the blessed saints—"With hat, umbrella, and guide book too."

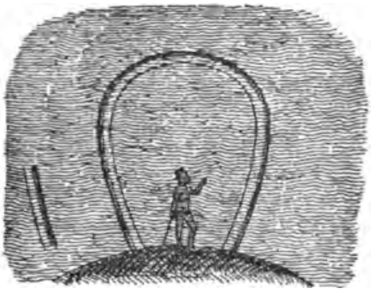

FIG. 3.

In answer to questions, Mr. Sawyer states :—

The shadow appeared to be, say 10 feet high, and 100 to 150 feet distant. The shadows of the Germans were inside the halo. They were about 10 feet from me.

(17.) *Alpine Journal.* London, Longmans. Vol. XI.

P. 370. Notes from Campfer. Mr. H. W. SETON-KARR. A few weeks before (that is before 15th August 1880), on Piz Nair, I observed the rare phenomenon, the Spectre of the Brocken, in great perfection. My situation was between the sun and a cloud. Being on the summit of a ridge my shadow was thrown on to the vapour, and appeared surrounded by a circle of prismatic colours. In these cases the observer sees his own shadow, and that of any one else near is invisible to him ; this phenomenon must be distinguished from a mere shadow cast upon a cloud, as when an aeronaut sees the shadow of his balloon. Piz Nair, 10,040 feet, is in the Bernina district.

(18a.) *Alpine Journal,* Vol. XI.

P. 482. A strange sight on Snowdon. Mr. HOWARD BARRETT writes : It has recently been my good fortune to witness a phenomenon amongst the hills of North Wales sufficiently rare to receive record and to interest mountaineers who are students of nature as well as climbers.

On January 20th last (1884) my friend Dr. Ambrose Fleming and myself left Pen-y-gwrid Inn (near the foot of Snowdon) to walk up the Glydr Vach. The rain was steadily descending as we set out, and everything fifty yards distant from the observer was hidden in a thick and impenetrable mist that was driving up from the westward before a strong wind. We reached the summit just at noon, and the sun, which for the last half hour had been making unsuccessful efforts to pierce the thick veil of clouds and vapour, was just then on the point of succeeding. We of course clambered up the minute aiguille or natural cairn of splintered rock that forms the actual summit, and which was just large enough to accommodate us both, and then looked northward and down towards the deep valley in which lies Lake Idwal. But both lake and valley were at first wholly obscured by great volumes of thin cloud and scud driving before the wind. Then all at once the sun, behind us and at no great altitude, burst forth through the clouds with brilliant rays, and we saw, to our astonishment, a circular rainbow, beautiful and complete ; and within this, framed as it were in the glowing spectrum, the shadows of ourselves and the upper part of the little peak on which we stood distinctly projected upon the mist. We waved our arms, and at once the shadowy arms wildly answered us. At one time the rainbow was reduplicated, the primary one being completely and concentrically surrounded by a secondary circle. The colours of the inner rainbow were very bright and in the order of the primary bow. The outer one was fainter. As the wind cleared the valley wholly of mist, these appearances vanished, and in their stead, and occupying much the same positions in the field of vision, lay Llyn Idwal far beneath, with Llyn Ogwen and both the Carnedds in the remote distance. But again the scud drove up and filled the valley, and once more the iris-circled phantoms reappeared ; and this alternate vanishing and reappearance continued for several minutes until the sun was obscured by a mass of clouds.

Owing to a certain degree of astigmatism in my eyes, to me the bow or bows looked rather ovoid than circular, but to my companion they appeared quite circular. An attempt made by Dr. Fleming, to whom the solution of optical problems comes naturally, to determine the angle subtended by the diameter of the primary bow, brought it out as probably not much above 20°. It would be interesting to learn if any other members of the club ever met with similar phenomena, for I imagine that, in the nature of things, it is given only to mountaineers, to those who ascend church steeples or topmasts of ships, or go up in the air in balloons, to behold such things. I suppose we are most of us familiar with shadows upon cloud or mist—the Spectre of the Brocken, for instance—but during eleven or twelve summers in the Alps I have never seen a circular rainbow. In answer to a question, Mr. Barrett said :—The shadows were rather larger than life.

(18b.) *Nature.* London, January 31st, 1884.

P. 310. Circular rainbow seen from a hill-top. Dr. J. AMBROSE FLEMING.

Staying last week for a couple of days at Pen-y-Gwrid, near Snowdon, in company with a friend, we walked one morning up the Glydr-Vach. The rain was steadily descending as we left the little inn, and the thick mist swathed the hill-sides in obliterating folds. Just as we reached the summit at noon a slight breeze thinned away the mist in front of the sun, and a burst of sunshine illuminated the hill-side. Clambering on to the natural cairn which crowns the summit, we looked down into the valley, in which lies the small lake Llyn Idwal. Along the valley the wind drove masses of thin mist or scud, and on this we saw to our surprise the shadow of the summit with our own sharply-marked shadows projected on it. We waved our arms, and the mystic figures replied by moving theirs. Surrounding these immense shadowy figures we could see two concentric rainbows completely circular, the centre being the shadow of our own heads. The colours of the inner rainbow were in the order of the primary bow, and the outer one was a secondary and more faintly tinted rainbow. During all this time the sun was shining brightly on our backs; when the wind cleared away the mist completely in the valley the shadows and the rainbows vanished, but reappeared when fresh masses of vapour were blown into a line with our shadows. A very rough attempt at determining the angle subtended by the diameter of the primary bow seemed to show that it was much less than 90°, in fact not probably above 20°. This interesting appearance lasted only for a few minutes, as the wind drove up fresh mist in front of the sun, and the rainbow-circled phantoms disappeared.

(19a.) *Alpine Journal.* Vol. XII.
P. 172. Mr. F. MORSHEAD, referring to Mr. Barrett, writes: – In April, about 12 years ago, I saw a precisely similar phenomenon in very nearly the same place. Mr. Kensington and myself were ascending the Tryfan from the north-east on a misty day. Just as we were standing in a nick on the *arête*, not far from the top, the sun suddenly burst out on our right, while the deep cwm on our left (Cwm Tryfan) was still filled with dense mist. On looking down into this cwm we saw a beautiful complete circular rainbow framing our shadows, which were projected on the mist just as described by Mr. Barrett, our own eyes in the shadows forming to each of us apparently the centre of the circle. This lasted for some time till the atmospheric conditions changed. I have several times, especially in Wales, seen shadows on the mist, but never except on this occasion a perfect circular rainbow.

In answer to a question, Mr. Morshead writes, the figures were not much larger than life.

(19b.) Mr. TH. KENSINGTON writes to Mr. Morshead, 16th February, 1887:—The cloud which we saw beneath us through the chasm was not very far off us, so our shadows at no time seemed gigantic to me; indeed, I should say that they did not look much larger than life size, though as the cloud receded or approached they appeared larger or smaller. Each of us saw his body projected on a series of concentric circles of rainbow hues, his head being of course the centre; and I think his height being about the radius of the largest circle. Each of us saw the other's shadow on the edge of the circle, there being some yards between us when we saw the phenomenon.

Further correspondence made it clear that Mr. Kensington meant a glory of a single set of rainbow colours in the right order, the inside touching the head of the shadow, and the outside reaching its feet.

(20 and 21a.) *Alpine Journal.* Vol. XII.
P. 173. Referring to Mr. Barrett, Mr. W. ASHBURY GREENE writes:—It may be worth while recording that under similar conditions to those mentioned by Mr. H. Barrett I saw circular rainbows in two consecutive years, 1878 and 1879. In 1878 it was in Norway from Mikletveitveten (3,647 feet), near Evanger, and in 1879 in Switzerland from the top of the Grosser Nesthorn (12,533 feet). In each case there was a complete circular rainbow, though, as I should gather from Mr. Barrett's description, hardly so bright as the one he saw, and each observer saw the shadow of *himself* only within the circle, whereas from the use of the word "ourselves" I suppose Mr. Barrett saw the shadows of his friend and himself.

In answer to questions, Mr. Greene says:—To the best of my recollection the shadow was considerably larger than life. Mr. Rickman was with him on the Nesthorn. Mikletveitven was at 3 p.m., 2nd September, and lasted say 10 minutes. The Grosser Nesthorn was 8 a.m., 8th September, and lasted about the same time.

(21b.) Letter to me from Mr. T. A. RICKMAN, Stoke-upon-Trent, 28th February, 1887, enclosing extract from his diary.

On Monday morning, September 8th, we started at a quarter to two to go up the Grosser Nesthorn. . . . The last hour is in an easterly direction along an *arête*, consisting of some careful icework and a casual rock or two. We got to the top at 7.45, just in time to get a good view for ten minutes, at the end of which time we were enveloped in mist. We had no view to the south-east, but all the rest was perfect. When we turned to go down we each saw our "fog bow," *i.e.* a slightly luminous oval, on the outside of which are the colours of the rainbow, enclosing your own shadow cast on the fog some 50 yards off by the sun behind you; the curious part is that each man sees his own shadow and oval, and cannot see the shadows of the others. Going down the *arête*, the fog in front was denser and the shadows clearer, and only 25 yards off; I wanted to try the experiment of one standing behind the other to see if we still each saw our own shadow, but before we got to a place where such an attitude was practicable the fog had lifted and the apparition vanished. *Letter, 3rd March.*—Shadow, roughly speaking, life size.

(22.) *Alpine Journal.* Vol. XII.

P. 174. Referring to Mr. Barrett, Mr. CLAUDE WILSON writes:—With three friends, I reached the top of Scawfell Pike at half past one o'clock on Christmas day, 1883. We mounted on the top of the cairn which marks the summit of the mountain. Our faces were turned in the direction in which the fog, which had hitherto enveloped us, was lifting, exposing in the distance a thick bank of white cloud, and we were spectators of a sight which is, I believe, rarely observed in these islands. The sun was shining brightly at our backs, and immediately before us, apparently at the distance of a quarter of a mile, there appeared a complete halo, elliptical in form and of the colours of the rainbow. In the centre of this we saw the images of our figures, exactly corresponding in shape, though gigantic in size. Every action on our part was faithfully reproduced on this atmospheric screen, and we amused ourselves for some time by testing the accuracy of this natural magic lantern. The effect was weird and beautiful in the extreme, and one could not help feeling that 50 years ago what we saw would have been ascribed to supernatural agency.

(23a.) *Alpine Journal.* Vol. XII.

P. 271. Dr. FREDERICK TAYLOR writes:—If it is not too late for the subject of circular rainbows to have any interest for the readers of the *Alpine Journal*, I should like to record that I was witness of one in Switzerland last August (1884), under circumstances similar to those described by your other correspondents. While staying at the Bel Alp, Mr. Gotch and I ascended the Grisighorn on August 13th, and were on the summit about four in the afternoon. As we sat under the shelter of the cairn facing towards the Sparrenhorn the sun was at our backs, and from time to time clouds rolled up before us from the rocks beneath. Suddenly we saw the shadow of the summit of the mountain and of ourselves thrown on the cloud, and at the same time a rainbow with the colours fully developed became apparent. As we sat, the rainbow was already more than the usual semicircle, and on mounting on the cairn I saw a complete circle of colours, with the red external, the violet internal. Of this circular rainbow my head was the centre, and my feet touched the lower limb. Mr. Gotch also saw a secondary bow. The phenomenon remained some time, varying in the brightness of the colours and the intensity of the shadow.

Dr. Taylor wrote to me, *March 1st*, 1887:—

In reference to the question you asked me in your letter of the 7th February, as to the size of the shadow that I saw on the Grisighorn in 1884, I find I have no actual notes, and I cannot lay my hands on the few notes, &c., that I put together before making my communication to the *Alpine Journal.* I have a rough sketch that I made at the time, and from that I should infer that the figure was a little larger than life (23b). On receiving your letter, I wrote to Mr. Gotch, who was with me on the Grisighorn; and he writes that his impression was that the shadow appeared life size at first when the cloud was thick or close—that later on the glacier became discernible below us, and then (the cloud being more distant) the shadow appeared gigantic—the difference being the result of a difference of impression as to the size, following different conceptions as to distance: and he suggests that two people at the same time might have different impressions as to the size of the shadow presented to them.

Dr. Taylor afterwards lent me two sketches that he had made of the phenomenon, and told me that the dark rays moved as he moved his arms. (Fig. 4)

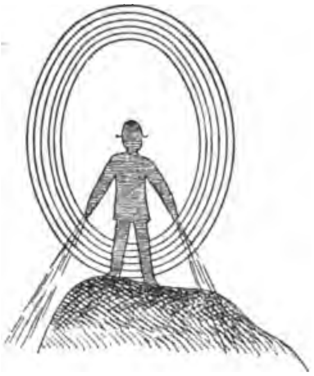

Fig. 4.—Taylor.

(24a.) *Nature*. London, February 14th, 1884.

P. 356. Circular rainbow seen from a hill-top. Mr. J. M. White, Spring Grove, Dundee. February 5th. Climbing several summers ago, with three friends, among the Coolin Hills in Skye, I was fortunate enough to witness phenomena similar to those described by Mr. Fleming in last week's *Nature* (p. 310). Our shadows were apparently thrown against the precipitous side of a deep corry, distant 200 feet, or perhaps more. They vanished and reappeared as thin mists passed through the corry, the sun shining continuously. We could not see each other's shadows unless close. The distance apart at which they became visible I do not clearly remember, but know it was approximately as one of my friends, Mr. W. A. Brown, writes:—"So long as we kept a few yards apart each could only see his own shadow, but when two were within arm's length a double shadow was visible to each, and on getting still nearer the shadows merged into each other." My estimate of the angle subtended by the diameter of the rainbow is 15°, that of my friend 10°. He adds, however, "I may be very far out in this."

Mr. White wrote to me, 18*th February*, 1887:—Our height above the sea was about 3,000 to 3,100 feet. As far as I remember, but I am not at all clear as to this, the shadows filled the circle somewhat as follows (Fig. 5). The eye, no doubt, was opposite the centre.

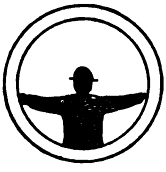

Fig. 5.—White.

(24b.) Mr. W. A. Brown writes to Mr. White.

2 Grosvenor Terrace, Dundee, 1st March, 1887. Yours with enclosure just received. As far as I can remember, the sketch represents exactly what we saw in Skye, the lower side of the circle merging into the shadow of the ridge on which we stood, but leaving visible about as much of the legs as the sketch shows. I do not recollect that the bow was coloured, but that it was merely a disc of light with the shadow projected on it, and also that if the arms were held out the disc

became distorted. Another point that I remember is that when two of us came near each other our discs cut in upon one another thus, Fig. 6, and that the whole thing became visible to both of us.

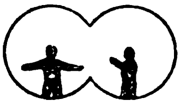

FIG. 6.—Brown.

When forwarding this, Mr. White wrote to me :—I cannot remember the distortion of the circle, but there was something peculiar when we came near each other.

As there was so much difference between the descriptions of Mr. White and Mr. Brown, I asked Mr. White to write to one of his other friends. Unfortunately the description that follows is not quite at the same time or place.

(25.) Letter to me from Mr. White, 16th March, 1887.

Herewith my friend's report. I wrote him, "I wish to simply mention that the size or angle subtended by the bow, and the behaviour of the shadows and bow as we moved about, are matters of chief interest." I remember the gap and shadows, but my description was of the effect at a slightly higher point, which he does not remember.

Mr. WHITE'S FRIEND writes :—About 2 p.m. we made for a deep cut in the ridge of hills at the head of Loch Corruisk. The cut was about 5′ or 6′ wide, and 30′ or 40′ deep. When there, we saw the brocken (*sic*) on the banks of mist in front of, but at an angle of about 30° below us, and apparently 60 to 100 yards distant. The circle of the halo was not complete, the greater part of the lower half being wanting. I would guess that the angle subtended by the halo was about 6°, probably if the circle had been complete, 8°. Only one figure was visible. When two of us stood in the gap the brocken was increased in breadth, and I think two heads could be seen, but the two figures were not separate. The cut was so narrow that two standing were almost touching, so that there was not much chance of getting separate brockens, and there could not be much, if any, lateral movement in the halo. Any movement made by arms or sticks was reproduced by the brocken. If I am correct in my idea that the diameter of the circle was 8°, then the figure would be 3°.

(26.) *Nature.* London, 14th February, 1884.

P. 356. Circular rainbow seen from hill-top. Mr. T. R. MAYNARD, the Black Forest, February 7th, 1884. Referring to Mr. Fleming's letter in *Nature* of January 31st (p. 310), I would state that many years ago, before Pontresina in the Grisons was so resorted to as it is now, I walked up the Piz Languard early one fine morning with an old smuggler and chamois hunter—the terms are synonymous on the frontier—named Colani. On the summit of the peak is a ledge of rock on which I lay down for twenty minutes' sleep. I had been asleep but a few minutes when Colani woke me, and, with excuses and an expression of fright in his face, begged me to come with him to see something which he had never seen in his life before. We moved to the western edge of the peak. Below us were some thin clouds of mist curling about like vapour from a large cauldron. On these clouds appeared a circular rainbow, and within it, as though in a gilded frame, were two figures, in fact the shadows of ourselves. "There are two of them now," cried Colani, and it was not until I told him to take off his hat and wave it, as I did mine, and he saw the action repeated by the figures, that he began to feel assured that they were not "Geister." It was not the "Arch St. Martin," a Romansch name for a rainbow, which had frightened him, though it was the first time he had seen a circular one, but the appearance of a dark solitary figure had awakened his conscience, for some of his smuggling adventures had not been without bloodshed. The details of the phenomenon were the same as those described by Mr. Fleming, with the exception, perhaps, that the figures were more vivid, and the whole spectacle of longer duration, owing to an unclouded sun.

(27.) Mr. Maynard continues :—
A similar appearance has lately been seen on the Tonjabe range in Nevada, by Mr. R. A. **Marr**, of the Coast and Geodetic Survey. I subjoin his description from the *Mail.*

"Suddenly, as I stood looking over the vast expanse beneath me, I saw myself confronted by a monster figure of a man standing in mid-air before me, upon the top of a clearly defined mountain peak, which had but the thin air of the valley below for a resting place. The figure was only a short distance from me. Around it were two circles of rainbow light and colour, the outer one faintly defined as compared with the inner one, which was bright and clear and distinctly irridescent. Around the head of the figure was a beautiful halo of light, and from the figure itself shot rays of colour normal to the body. The sight startled me more than I can tell. I threw up my hands in astonishment, and perhaps some little fear, and at this moment the spectre seemed to move towards me. In a few moments I got over my fright, and then, after the figure had faded away, I recognised the fact that I had enjoyed one of the most wonderful phenomena of nature. Since then we have seen it once or twice from Jeff Davis peak, but it never created such an impression on me as it did that evening when I was doing service as a heliotroper all alone on the top of Arc Dome."

(28.) *Nature.* London, February 28th, 1884.
P. 406. Circular cloud bows. Mr. E. H. L. **Firmstone**, Bewdley, February 21st, 1884. I fancy that the phenomenon described by Mr. Fleming in your issue of January 31st (p. 310) is not a very uncommon one. It has twice fallen to my lot when in Switzerland to be a witness of these spectral shadows. On the first occasion I was with a party of three on the mountains to the north-east of Montreux, almost opposite the Cape de Moine. It was midwinter, and the day was very cloudy even in the valleys, while the high ground on which we stood, and all the surrounding peaks, were completely swathed in mist. Suddenly, and under the impulse apparently of a blast of wind from below, the mists around us were almost entirely dissipated, and a few sickly gleams of sunshine filtered through the fog. At that moment we saw two gigantic images of ourselves projected on to the wall of vapour enshrouding the Cape de Moine, immediately opposite the point where the sunbeams had permeated. The effect was very transitory, and, so far as I can remember, there were no prismatic colours.

(29.) Mr. **Firmstone** continues :—
The circumstances under which I saw the second appearance were as follows :— In August last, 1883, I was standing just before sunset on the summit of the Niesen, in company with a friend. The day had been very hot, and we were just remarking on the extraordinary difference in temperature between our elevated position there and our situation a few hours before on the Lake of Thun, when we saw some scattered wisps of cloud rising out of the depths below. They increased rapidly, both in size and number, uniting as they rose till the whole abyss presented the appearance of a seething cauldron, from which was escaping a dense cloud of steam. The prospect towards the east was quickly blotted out, while the sky in the opposite quarter remained as clear as before. We then saw dim and fragmentary signs of prismatic colours in the curtain of cloud, and these became more defined and vivid as the thickness of the cloud increased. Finally, there appeared a very distinct circle of rainbow hues, with our own figures looming, weird and awful, in its centre. Both images were visible to myself and my companion, though each could see the other's reflection more clearly than his own.

(30.) *Nature.* London, April 10th, 1884.
P. 550. Ice Volcanoes, Mountain Rainbow, A. P. **Coleman**, Faraday Hall, Victoria University, Coburg, Canada. Mr. J. A. Fleming mentions in your issue for January 31st (p. 310) a circular rainbow seen from a hill-top against mist. I saw the same phenomenon three years ago near the Lofoden Islands, as a fog was breaking. It was noticed and admired by other passengers on the steamer also. Each saw his shadow enlarged upon the mist, and the head surrounded by a brightly coloured halo or rainbow. The beautiful sight disappeared after a few minutes as the fog thickened again.

In answer to a letter from me, Mr. Coleman wrote, February 23rd, 1887:—My recollection of the phenomenon seen among the Lofoden Islands is that it was a real rainbow, or rather fogbow, seen at a very close range. It formed much more than a semicircle, and was not cut off by the horizon, but swept almost or altogether down to the shadow somewhat thus (Fig. 7.) the shadow was quite distinct, and the sun rather low; the colours were fainter than in an ordinary rainbow, but still very distinct; and the whole affair appeared to be within a few yards of me, between the steamer's bulwarks and the water, which was perfectly calm and scarcely visible through the mist even at that short distance. I should not like, however, to lay too much stress on my memory of the distance between the shadow and the coloured circle. My notes at the time (very brief) call it a fogbow.

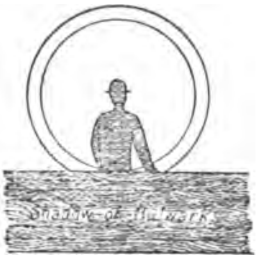

FIG. 7.—Coleman.

OTHER SHADOWS AND BROCKEN BOWS.

(31.) *The History and present State of Discoveries relating to Vision, Light and Colours*, by Joseph Priestley, LL.D., F.R.S. London, 1772.

P. 600. Similar also to this curious appearance (*Bouger's*) was one that was observed by Dr. McFAIT in Scotland. This gentleman observed a rainbow round his own shadow in the mist, when he was upon an eminence above it. In this situation the whole country round seemed, as it were, buried under a vast deluge, and nothing but the tops of distant hills appeared here and there above the flood, so that a man would think of diving down into it with a kind of horror. In those upper regions the air, he says, is at that time very pure and agreeable to breathe in.

(32.) *Philosophical Transactions*. London, 1835. On the Atmospheric Tides, &c., of Dukhan (Deccan). By Lieutenant-Colonel SYKES, F.R.S., &c.

P. 194. About the middle of March fogs commence to rise, at uncertain intervals, from the Konkum.

It was during such periods that I had several opportunities of witnessing that singular phenomenon the circular rainbow, which, from its rareness, is spoken of as a possible occurrence only. The stratum of fog from the Konkum on some occasions rose somewhat above the level of the top of a precipice forming the north-west scarp of the hill-fort of Hurreechundurghur, from 2,000 to 3,000 feet perpendicular, without coming over upon the table-land. I was placed at the edge of the precipice just without the limits of the fog, and with a cloudless sun at my back at a very low elevation. Under such a combination of favourable circumstances the circular rainbow appeared quite perfect, of the most vivid colours, one half above the level on which I stood, the other half below it. Shadows in distinct outline of myself, my horse and people appeared in the centre of the circle as in a picture, to which the bow formed a resplendent frame. My attendants were incredulous that the figures they saw under such extraordinary circumstances could be their own shadows, and they tossed their arms and legs about, and put their bodies into various postures, to be assured of the fact by the corresponding movements of the objects within the circle; and it was some little time ere the superstitious feeling with which the spectacle was viewed wore off. From our proximity to the fog I believe the diameter of the circle at no time exceeded 50 or 60 feet. The brilliant circle was accompanied with the usual outer bow in fainter colours.

I witnessed these phenomena on the 29th of April, the 9th, 11th and 12th of May, 1829, on the hill fort of Hurreechundurghur.

(33.) *Alpine Journal.* Vol. II. 1865-6.
P. 244. The following is from an article out of the "Feuille d'Aoste," October 1865. It describes what was seen on 17th July, 1865, by the writer and others as they were coming down after the first ascent of the Matterhorn from the Italian side. The Abbé **Ame Goret**. Suivant notre *corridor*, nous revîmes jusque sur l'arête d'où l'on voit Valtournanche et où déjà nous aurions dû passer en montant; de là à *l'épaule*, ce ne fut qu'un moment: il n'y avait pas de danger par là. Après avoir repris nos provisions sur le roc (nous n'eûmes pas le temps de manger, c'etait trop tard), nous étions sur *l'épaule*, quand nous remarquâmes un phénomène qui nous fit plaisir; le nuage était très dense du côté de Valtournanche, c'était serein en Suisse; nous nous vîmes au millieu d'un cercle aux couleurs de l'arc en ciel; ce mirage nous formait à tous une couronne au millieu de laquelle nous voyions notre ombre.

(34.) *Alpine Journal.* Vol. XII.
P. 273. The Rev. F. T. **Weatherhead** writes:—I should like to record a remarkably clear fogbow seen on August 10th, 1875. Christian Almer, Aloys Pollinger and I were descending to the "shoulder" of the Matterhorn (rather more than half way down between the shoulder and the top) when I saw distinctly in the mist, to our proper right, in the direction of the north-east arête, a perfectly defined circle composed of clearly coloured and concentric rings. The bow appeared as though 35 feet from our line of descent, and to be of 2 or 3 yards in diameter. In the centre, diametrically between the inside of the upper and lower arc of the circle, my whole figure was photographed in black, and in the minutest detail. The weather was bad, and there was no apparent sunlight. The bow was seen by me for several seconds at about 3 p.m.

(35.) *Alpine Journal.* Vol. XII.
P. 172. Referring to Mr. Barrett, Mr. **Gerald E. Maude**:—I write to say that I saw such a phenomenon on the Wetterhorn on the 2nd October, 1878. I made the ascent with Karl Hess, of Engelberg, and Peter Schlegel, and we were joined at the old Gleckstein hut by a gentleman living in London, whose name was, I remember, Schmitz-Werotte, and who had as chief guide poor old Peter Bohren. The weather was very bad all night, and it was still snowing when we made the ascent. When we reached the summit, about ten o'clock, we were just above the clouds, and the sun was shining brightly, while the tops of the highest mountains in the neighbourhood were visible above the white mass which obscured all view below us. As we stood with the sun behind us we became aware of a prismatic halo on the clouds somewhat below our level, in the centre of which each of us saw his own shadow. I cannot remember exactly whether the shape of the frame of the picture, so to speak, was circular, or, as Mr. Barrett saw it, ovoid, but am inclined to think it was the former. The effect was very weird and striking, &c. &c.

In answer to a letter from me, Mr. Maude wrote, 21/2/87:—I do not think that the shadow I saw was much if at all larger than life, . . . it appeared to be tolerably near.

(36.) *Alpine Journal.* London, Vol. XII.
P. 174. Referring to Mr. Barrett, Herr A. **Wueste** reports in the *Oester. Alpenzeitung* (1884, p. 246) that on August 11th last (1884), at 7 a.m., when on the summit of the Ortlerspitze I saw my own shadow thrown on a bank of cloud, and surrounded by a double rainbow, the outer one being the fainter. Seventeen persons were standing beside me, and each saw only his own shadow.

(37.) *The peculiar Sunrise Shadows of Adam's Peak in Ceylon.* By the Hon. **Ralph Abercromby**, F.R.Met.Soc., read before the Physical Society on November 13th, 1886, from the *Philosophical Magazine* for January 1887.

P. 31. . . . Our party reached the summit on the night of the 21st February, 1886, amid rain, mist and wind. Towards morning the latter subsided. . . . At 6 a m. the thermometer marked 52° F. . . . Shortly after the sun rose behind a cloud, . . . but suddenly, at 6.30 a.m., the sun peeped through a chink in the clouds, and we saw the pointed shadow of the Peak lying on the misty land. Driving condensed vapour was floating about, and a fragment of rainbow-tinted mist appeared near the top of the shadow. Soon this fragment grew into a complete prismatic circle of about 8° diameter by estimation, with the red outside, formed round the summit of the Peak as a centre. The author instantly saw that with this bow there ought to be spectral figures, so he waved his arms about, and immediately found shadowy arms moving in the centre of the rainbow. Two dark rays shot upwards and outwards on either side of the centre, as shown in Fig. 8, and appeared to be nearly in prolongation of the lines of the slope of the Peak below. The centre of the bow appeared to be just below the point of the shadow, not on it, because we were standing on a platform below a pointed shrine, and the subjective bow centred from our own eyes. If we did not stand fairly out in the sun only a portion of the bow could be seen. Three times within a quarter of an hour this appearance was repeated, as mist drove up in proper quantities and fitful glimpses of the sun gave sufficient light to throw a shadow and form a bow. . . . .

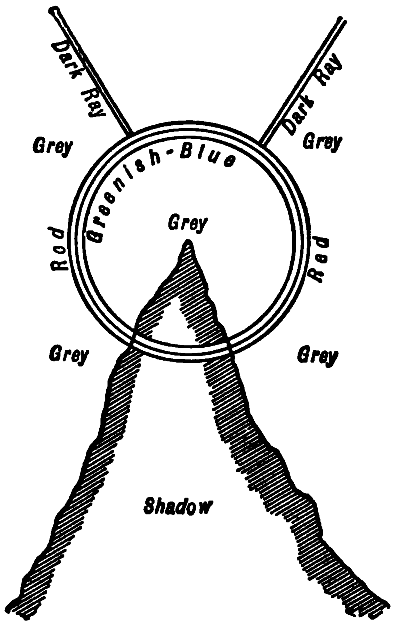

Fig. 8.—Abercromby.

About an hour later the sun again shone out, but much higher and stronger than before, and then we saw a brighter and sharper shadow of the Peak, this time encircled by a double bow. Our own spectral arms were again visible. . . . The inner bow was the one we had seen before; the outer and fainter one was due to stronger light.

The bows were all so feeble and the time so short, that the author did not succeed in obtaining any sextant measurements of the diameters of the bows. Adam's Peak is 7,352 feet above the sea.

In answer to a letter from me, Mr. Abercromby wrote, *March 9th*, 1887:—The dark rays, had no connection with the shadows of my arms, and did not move about with them. . . . . The shadow of the arms never nearly reached the encircling bow. When, later on, I saw a double bow, I did not notice whether the colours of the outer one were in the reverse order of the inner bow, as I was busy photographing.

(37½.) *The Arctic Regions*, &c., by Captain SCORESBY, F.R.S.E. London, 1849. Abridged from Scoresby's *Arctic Regions and Whale Fishery*. Edinburgh, 1820.

P. 121. *Rainbows* are common in these regions, but the *fog-bow*, or *fog-circle*, is more rarely observed, and is entitled to our attention. It is a circle depicted on the fog, which prevails in the Polar Seas at certain seasons, resting upon the surface of the water, and seldom reaching to a considerable height. On the 19th July, 1813, I observed one of about 30° diameter, with bands of vivid colours depicted on the fog. The centre of the circle was in a line drawn from the sun, through the point of vision, until it met with the visible vapour in a situation exactly opposite the sun. The lower part of the circle descended beneath my feet to the side of the ship, and although it could not be 100 feet from the eye, it was perfect, and the colours distinct. The centre of the coloured circle was distinguished by my own shadow, the head of which, enveloped by a halo, was most conspicuously portrayed. I remained a long time contemplating the beautiful phenomenon before me.

SUNDRIES.

(38.) *The History and present State of Discoveries relating to Vision, Light and Colours*, by Joseph Priestley, LL.D., F.R.S. London, 1772.

At another time he (Dr. MCFAIT) observed a double range of colours round his shadow in these circumstances. The colours of the outermost range were broad, and very distinct, and everywhere about 2 feet distant from the shadow. Then there was a darkish interval, and after that another narrower range of colours, closely surrounding the shadow, which was very contracted.

(39.) *Scrambles amongst the Alps in the years* 1860-69, by EDWARD WHYMPER. London, 1871.

P. 399. About 6 p.m. we arrived at the snow upon the ridge descending towards Zermatt, and all peril was over. We frequently looked, but in vain, for traces of our unfortunate companions; we bent over the ridge and cried to them, but no sound returned. . . . When, lo! a mighty arch appeared, rising above the Lyskamm, high into the sky. Pale, colourless and noiseless, but perfectly sharp and defined, except where it was lost in the clouds, this unearthly apparition seemed like a vision from another world; and, almost appalled, we watched with amazement the gradual development of two vast crosses, one on either side. If the Taugwalders had not been the first to perceive it, I should have doubted my senses. They thought it had some connection with the accident, and I, after a while, that it might bear some relation to ourselves. But our movements had no effect upon it. The spectral forms remained motionless. . . . . I paid very little attention to this remarkable phenomenon, and was glad when it disappeared, as it distracted our attention. . . . The sun was directly at our backs; that is to say, the fog-bow was opposite the sun. The time was 6.30. The forms were at once tender and sharp, neutral in tone, were developed gradually, and disappeared suddenly. The mists were light (that is, not dense), and were dissipated in the course of the evening.

LIST OF REFERENCES NOT FOUND IN THE BRITISH MUSEUM.

Naturforschende Gesellschaft Versuche und Abhandlungen. Vol. IV. The only Society of that name at that time was at Danzig, and there are only three vols.

Adolph Traugott von Gersdorff, Kurze Nachrichten, in the *Wittenberg Wochenblatt*. 1791, I.

Silberhaar, Papers in the *Bul. naturw. Sekt. Schles. Ges.* 1826. IX. *Fata Morgana*. 1828. VIII. and IX. *Luftspiegelung*.

[This means the *Bulletin* of the Natural History Section of the Silesian Society, &c. &c. I have found the *Uebersicht* of the Society, which refers to the Bulletin, but not the Bulletin itself.]

DISCUSSION.

Capt. **Toynbee** said he remembered seeing a phenomenon resembling a Brocken Spectre when staying at a mountain hotel in Switzerland. It was a foggy evening; and after the lights in the hotel were lit, on looking out of the window, he saw his shadow thrown on the fog.

Dr. **Marcet** said he had met with the Brocken phenomenon nine years ago on the Righi, near Lucern, when he observed his shadow on a bank of clouds rising from the Lake of Zug. The outline was not sharp, but the shadow of the head, body, arms and legs was distinctly visible, and increased in size; there was a glory round the head, and the rainbow colours were well marked. His companion observed the same phenomenon. While on the Peak of Teneriffe he had seen, shortly before sunset, the shadows of the Peak projected on the sea of clouds about 4,000 feet below him, and had noticed a curious smoke-like stream appended to and radiating from the summit of the shadow; it was very similar to the elongation of the arms depicted in one of the Brocken Spectres exhibited by Mr. Sharpe. He had noticed that persons seen in a fog appeared larger than they actually were, assuming their natural size as they approached near. When travelling on the Nile, while the Khamsin blew, he saw objects—two men and a donkey—on the opposite side of the river, looking, he thought, somewhat larger than usual, as they appeared indistinctly through a cloud of dust, but this he thought was probably an optical illusion.

Mr. **Tripp** said he had noticed the curious effect which fog produced in magnifying objects seen through it.

Mr. **Eaton** said that on July 20th, 1877, he had witnessed the phenomenon of the "Brocken Spectre" from the ridge of the Grand Chammossaire, above Aigle, in Canton Vaud, Switzerland. The weather had been rather showery, but was clearing under the influence of a Westerly or North-westerly wind. The upland basin, however, in which are situated the little villages of Chesieres and Villard, south-east of the ridge in question, was filled with cloud, while the sky to the westward of the ridge, and the ridge itself, were quite clear. The temperature of the air was probably about 55°, and the elevation above sea-level somewhat under 6,000 feet. It was about 4 p.m. when his companion and himself, walking along the ridge towards the summit of the mountain, all of a sudden perceived each his own shadow on the wall of cloud to their right, which was not more than 20 or 30 feet distant. The shadow did not appear of abnormal dimensions, and was surrounded by a circle, which, so far as he remembered, had a diameter about twice the length of the shadow, the head occupying the centre of the circle. The cloud was decidedly brighter inside the circle than outside, and there was a considerable access of light around the head of the shadow. The appearance lasted two or three minutes.

Mr. **Abercromby** could not agree with the author that glories were not connected with fog-bows. They both belonged to a set of concentric prismatic rings; the glories being the inner smaller series, the bows the larger outer series. The formation of either or both sets depended on the intensity of illumination, and especially on the density and size of drops in the fog.

He thought shadows of figures could be thrown on a vertical wall of fog at a much greater distance than the author supposed. Such shadows could not be compared with the shadows on the ground, for the latter are thrown on a horizontal plane.

As regards the bow seen on Adam's Peak, he (Mr. Abercromby) had not given much attention to the details, as he was under the mistaken impression that the theory was well known. His whole attention was directed at the time to seeking the source of a peculiar lifting and falling of the shadow, and in an attempt to photograph the whole appearance.

Mr. **Laughton** said that he had occasionally seen a colourless glory, or what Mr. Eaton had rightly called "an accession of light," round the head of his shadow as thrown by the moon on grass wet with heavy dew. He thought that this phenomenon, which appeared to depend on the fine particles of moisture on the grass, might be akin to some of those described in the paper. As to the rough and ready measurement of angles, it might be worth reminding the Fellows that the span from thumb to end of second finger, at arm's length, subtends an angle of 15°; to end of little finger an angle of 18°.

Mr. **Symons** drew attention to the confusion which observers made between the lunar halo and lunar corona, and pointed out the desirability of the two being kept distinct, as there was a total difference in the conditions which produced halos and coronæ.

Mr. **Inwards** pointed out, by means of a drawing on the black board, that it was quite possible for the shadow to be considerably enlarged by numerous reflections of the light by various cloud surfaces before it arrived at the spectator casting the shadow, and the Spectre might also *appear* larger from being thrown on a sloping or varying surface of cloud or fog. He considered the apparently gigantic size of the Spectre might often be really due to the projection of many shadows partially overlapping each other, and such as would be produced by beams of light reflected from various surfaces.

Mr. **Sharpe**, in reply, said that, in spite of Mr. Inwards' suggested explanation, he considered the supposed large size of the figure was due to a mistake in judging the distance. He then pointed out the differences between the "glory" and the "bow," and stated that out of nineteen descriptions of the "glory" which he had been able to collect, no two agreed in colour, but that all the "bows" agreed in colour. Neither could he find any satisfactory theory as to the cause of the formation of the phenomena.

RESULTS OF THERMOMETRICAL OBSERVATIONS

Made at 4 Feet, 170 Feet and 260 Feet above the Ground at Boston, Lincolnshire, 1882-86.

By WILLIAM MARRIOTT, F.R.Met.Soc., Assistant Secretary.

[Read May 18th, 1887.]

It will be remembered that the Council, in their Report for the year 1881, stated that they considered it desirable that an endeavour should be made to obtain accurate and complete information respecting the vertical decrement of the temperature of the air. As a step in this direction it was decided that simultaneous observations of temperature should be taken at the summit and base of Boston Church Tower, Lincolnshire, which rises to the height of 278 feet in a very flat country, quite free from any obstructions.

The Vicar (Canon Blenkin) and the Churchwardens gave the necessary permission for fixing up the instruments, and the Verger, the late Mr. E. C. Hackford, a very careful and competent observer, undertook to make the observations.

The late Sir William Siemens, F.R.S., kindly placed at the disposal of the Council one of his Electrical Thermometers, which permitted the readings to be taken below, without climbing to the top of the tower for each observation.

The principle of this instrument is explained by Sir W. Siemens in his Paper "On the Dependence of Electrical Resistance on Temperature," printed in the *Journal of the Society of Telegraph Engineers*, Vol. III. p. 816. The thermometer consists of a coil of wire wound round a cylindrical piece of wood enclosed in a small brass tube; a third wire is joined to one of the wires, and the three, insulated by gutta-percha, form a light cable, which may have any length, and is connected to a galvanometer, the terminals of which are in connection with the poles of a six-cell Leclanché galvanic battery. The instrument is read by depressing a key, which causes the needle of the galvanometer to deflect; a pointer or vernier (moving a contact roller upon a wire in a circular groove) is then pushed to the right or to the left upon a divided scale until the needle remains stationary on the zero point, when the electrical resistance of the wire is measured upon the scale. The number indicated by the vernier is then read off, and by referring to a table of equivalents, the actual temperature in degrees of Fahr. is readily ascertained.

The electrical thermometer was tested at the Kew Observatory and found to work very satisfactorily, though it was rather sluggish.

On February 27th, 1882, I went to Boston to superintend the fixing of the instruments. The electrical thermometer was placed in a wall-screen on a pinnacle on the north of the tower facing West-south-west, at a height of 260 feet above the ground. A board was fastened on the south side of the screen to protect it from the sun's rays. (Subsequently an outer screen was placed over the wall-screen.) An ordinary thermometer was also mounted in the screen along with the electrical one, to be read occasionally as a check upon the other. The cable was brought down the inside of the tower, then through the belfry, and so to the base of the tower inside the church. A strong box or cupboard, with a solid top for a table, was fixed in a recess on the south side of the base of the tower, the galvanometer being placed on the top and the battery on a shelf inside. The cable was brought through this cupboard at the bottom, and passed on to the binding-screws on the table in connection with the galvanometer.

A Stevenson screen, containing dry, wet, maximum and minimum thermometers, was fixed in the south-east angle of the tower, above the roof of the belfry, at a height of 170 feet above the ground. The inside of the tower above the roof of the belfry is open upwards and fully exposed to the sky. The large open windows on each side of the tower also allow the air to circulate freely over the roof of the belfry—in fact the air there is nearly always in motion.

Another Stevenson screen, containing dry, wet, maximum and minimum thermometers, was placed in the churchyard where there was a good exposure. The surface of the ground is 16 feet above sea-level.

The accompanying engraving gives a view of Boston Church, taken from the Market-place, and looking West-north-west.

All the instruments were read daily at 9 a.m.; and readings of the electrical thermometer on the top of the tower, and the dry and wet bulbs in the screen in the churchyard, together with the direction and force of the wind and the amount of cloud, were also regularly made at 11 a.m., 1, 3, 5, 7 and 9 p.m., from March to December 31st, 1882.[1]

Mr. Hackford fell ill at the beginning of 1883, and died on February

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[1] The results of the observations from April to December 1882 have been embodied in a Paper by Mr. G. J. Symons, F.R.S., printed in the *Proceedings of the Royal Society*, Vol. XXXV. p. 310.

BOSTON CHURCH, LINCOLNSHIRE.
TOWER FROM WHICH THE OBSERVATIONS WERE MADE.

20th, 1884. The observations were consequently discontinued during this period. Arrangements were subsequently made with his son, Mr. G. E. Hackford (who had been appointed Verger in his father's place), by which the observations were resumed on May 1st, 1884, and continued till April 30th, 1886. The daily readings were less numerous, being limited to the hours of 9 a.m., 1 p.m. and 9 p.m. The observations, however, from May to August, 1884, were not quite satisfactory, and the results have therefore not been incorporated in the accompanying Tables.

On several occasions during the winter months hourly observations were made from 7 p.m. on Saturdays to 9 p.m. on Sundays, the night observations being taken by the man who was in attendance at the church to regulate the heating apparatus.

Table I. gives the monthly means of the maximum, minimum, and 9 a.m. temperatures at 4 feet in the churchyard and at 170 feet on the belfry for the twenty-nine months, April to December 1882, and September 1884 to April 1886.

From this it will be seen that in every month the mean maximum temperature at 4 feet exceeds that at 170 feet, the differences ranging from 8°·1 in July to 0°·8 in December. The mean minimum temperature at 4 feet is

TABLE I.—MONTHLY MEAN TEMPERATURES AT 4 FEET AND 170 FEET—CHURCHYARD AND BELFRY.

Month.	Maximum.			Minimum.			9 a.m.		
	4 ft.	170 ft.	Diff.	4 ft.	170 ft.	Diff.	4 ft.	170 ft.	Diff.
1882.	°	°	°	°	°	°	°	°	°
April	53·4	50·9	−2·5	40·3	40·5	+0·2	46·8	45·2	−1·6
May	60·3	57·4	2·9	43·8	44·9	+1·1	53·4	51·2	2·2
June	63·2	60·6	2·6	49·0	48·9	—0·1	56·3	54·6	1·7
July	68·4	65·4	3·0	52·2	52·6	+0·4	60·8	58·6	2·2
August	66·3	63·9	2·4	52·0	52·6	+0·6	59·4	57·7	1·7
September	61·3	59·5	1·8	47·4	48·6	+1·2	54·3	53·1	1·2
October	55·3	54·3	1·0	44·8	45·2	+0·4	49·6	49·0	0·6
November	46·7	46·0	0·7	37·4	37·8	+0·4	41·1	41·0	0·1
December	42·4	42·0	0·4	34·2	34·1	—0·1	37·7	37·5	0·2
1884.									
September	65·2	63·4	1·8	51·3	52·1	+0·8	58·7	57·8	0·9
October	54·8	53·8	1·0	42·2	42·8	+0·6	48·5	48·0	0·5
November	46·1	45·4	0·7	36·8	37·0	+0·2	41·0	40·8	0·2
December	43·7	43·0	0·7	35·5	35·2	—0·3	38·9	38·9	0·0
1885.									
January	39·9	39·3	0·6	32·8	32·3	—0·5	35·7	35·5	0·2
February	47·7	46·4	1·3	37·3	36·9	—0·4	41·1	40·7	0·4
March	46·8	44·9	1·9	34·2	33·7	—0·5	39·4	39·0	0·4
April	53·6	51·2	2·4	40·6	40·1	—0·5	47·6	46·4	1·2
May	55·5	52·9	2·6	40·7	40·5	—0·2	49·5	47·9	1·6
June	65·9	63·0	2·9	49·4	49·8	+0·4	58·8	57·1	1·7
July	69·7	66·6	3·1	52·7	53·5	+0·8	62·3	60·9	1·4
August	63·7	60·9	2·8	50·6	50·9	+0·3	57·7	56·3	1·4
September......	62·3	60·3	2·0	47·2	47·8	+0·6	54·2	53·7	0·5
October	51·0	49·7	1·3	40·4	40·5	+0·1	45·7	45·2	0·5
November	46·7	45·9	0·8	38·8	38·8	0·0	42·5	42·3	—0·2
December	42·5	42·2	0·3	32·1	32·1	0·0	36·6	36·9	+0·3
1886.									
January........	39·3	38·8	0·5	31·2	31·4	+0·2	35·0	34·8	—0·2
February	37·4	36·2	1·2	30·0	29·7	—0·3	33·1	32·5	0·6
March	44·6	43·0	1·6	34·5	34·3	—0·2	39·9	38·9	1·0
April	50·5	48·4	—2·1	38·6	38·5	—0·1	45·7	44·3	—1·4

generally colder than that at 170 feet except in the winter months, when the latter is slightly colder than the former. At 9 a.m. the mean temperature in the churchyard is, with one exception, always in excess of that on the belfry, the difference being greatest in the summer.

Table II. gives the monthly means of the readings of the thermometer at 4 feet in the churchyard and of the electrical thermometer at 260 feet on the tower for every two hours during the day, from 9 a.m. to 9 p.m., from April to December 1882; while Table III. gives similar results for the hours 9 a.m., 1 p.m. and 9 p.m., from September 1884 to April 1886.

From these Tables it will be seen that the mean temperature at 4 feet, during the day hours, is always in excess of that at 260 feet, the difference during the summer months amounting to about 4° at the warmest part of the day. As night comes on the difference becomes much less.

The general results therefore show that the diurnal range of temperature is much less at the top of the tower and on the belfry than at 4 feet above the ground.

An examination of the individual readings for each day brings out the

TABLE II.—MONTHLY MEAN TEMPERATURES AT 4 FEET AND 260 FEET—CHURCHYARD AND TOWER.

Month.	9 a.m.			11 a.m.			1 p.m.			3 p.m.		
	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.
1882.	°	°	°	°	°	°	°	°	°	°	°	°
April	46·8	44·8	—2·0	49·4	47·3	—2·1	51·1	49·5	—1·6	51·4	49·4	—2·0
May	53·4	51·0	2·4	56·1	53·3	2·8	57·7	54·7	3·0	57·6	54·8	2·8
June	56·3	53·6	2·7	59·0	55·9	3·1	60·7	57·9	2·8	60·3	57·3	3·0
July	60·8	57·2	3·6	63·7	60·1	3·6	65·5	62·2	3·3	65·8	62·7	3·1
August	59·4	56·4	3·0	62·6	59·5	3·1	64·1	61·2	2·9	63·9	61·0	2·9
September	54·3	52·2	2·1	57·7	55·5	2·2	59·3	57·6	1·7	59·5	57·1	2·4
October	49·6	48·4	1·2	52·6	51·0	1·6	54·4	52·5	1·9	54·1	52·3	1·8
November	41·1	40·6	0·5	43·8	42·6	1·2	45·0	43·6	1·4	44·8	43·6	1·2
December	37·7	37·5	—0·2	38·9	38·1	—0·8	40·4	39·2	—1·2	40·2	39·6	—0·6

Month.	5 p.m.			7 p.m.			9 p.m.		
	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.
1882.	°	°	°	°	°	°	°	°	°
April	50·2	49·1	—1·1	47·2	46·7	—0·5	45·4	44·9	—0·5
May	56·6	54·0	2·6	53·8	52·2	1·6	50·7	50·2	0·5
June	59·6	57·0	2·6	57·6	55·5	2·1	54·2	52·9	1·3
July	64·5	61·7	2·8	61·3	59·2	2·1	58·1	57·0	1·1
August	62·9	60·3	2·6	60·0	58·1	1·9	57·7	56·3	1·4
September	57·7	55·9	1·8	55·3	54·4	0·9	53·4	53·1	0·3
October	52·2	51·1	1·1	50·8	50·0	0·8	50·0	49·4	0·6
November	43·1	42·5	0·6	42·1	41·6	0·5	41·7	41·5	0·2
December	39·3	39·1	—0·2	38·9	38·1	—0·8	38·5	37·6	—0·9

TABLE III.—MONTHLY MEAN TEMPERATURES AT 4 FEET AND 260 FEET—CHURCHYARD AND TOWER.

Month.	9 a.m.			1 p.m.			9 p.m.		
	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.
1884.	°	°	°	°	°	°	°	°	°
September	58·7	55·5	—3·2	63·5	59·9	—3·6	56·6	55·0	—1·6
October	48·5	46·4	2·1	53·4	50·7	2·7	47·7	46·6	1·1
November	41·0	39·5	1·5	44·9	42·7	2·2	41·2	40·0	1·2
December	38·9	38·1	0·8	41·5	40·2	1·3	39·7	38·8	0·9
1885.									
January	35·7	34·5	1·2	38·6	36·7	1·9	36·5	35·0	1·5
February	41·1	39·4	1·7	46·4	44·3	2·1	42·0	41·1	0·9
March	39·4	37·1	2·3	45·0	42·2	2·8	39·2	38·5	0·7
April	47·6	45·0	2·6	51·9	48·5	3·4	45·0	43·7	1·3
May	49·5	46·1	3·4	52·0	48·3	3·7	47·5	45·4	2·1
June	58·8	55·4	3·4	63·8	59·5	4·3	56·1	54·1	2·0
July	62·3	59·3	3·0	67·5	63·6	3·9	60·7	58·8	1·9
August	57·7	54·6	3·1	61·3	57·9	3·4	55·5	53·4	2·1
September	54·2	51·3	2·9	59·8	56·5	3·3	53·1	51·7	1·4
October	45·7	43·3	2·4	49·3	46·4	2·9	45·0	43·0	2·0
November	42·5	..	..	..	..	..	..	..	..
December	36·6	35·4	1·2	40·1	37·7	2·4	38·1	36·8	1·3
1886.									
January	35·0	32·9	2·1	37·6	35·0	2·6	34·7	32·6	2·1
February	33·1	31·6	1·5	36·2	33·9	2·3	33·4	32·1	1·3
March	39·9	37·7	2·2	43·2	40·7	2·5	39·1	37·7	1·4
April	45·7	42·4	—3·3	48·1	44·8	—3·3	42·8	40·9	—1·9

following features, viz. 1. that in fine bright weather the temperature at 4 feet during the day is much higher than on the top of the tower, the difference in summer occasionally amounting to 5° at 1 p.m.; 2. that in foggy weather the temperature at the top of the tower is always warmer than at 4 feet, the upper part of the tower being generally free from fog; and 3. that in cloudy and wet weather the temperature is uniformly higher at 4 feet than at the top of the tower.

The following instances during 1882, showing great differences of temperature between the churchyard and tower, are very interesting:—

March 15th, 9 p.m. 4 ft. 45°·1; 260 ft. 51°·7. Fog.

March 18th, 9 a.m. 4 ft. 41°·4; 170 ft. 43°·8; 260 ft. 45°·9. Fog, but bright at top of tower.

June 9th, 1 p.m. 4 ft. 58°·3; 260 ft. 51°·5. Thunder, with rain at times.

October 9th, 9 a.m. 4 ft. 44°·5; 170 ft. 46°·2; 260 ft. 48°·1.—11 a.m. 4 ft. 50°·7; 260 ft. 52°·0. Dense fog at 9 a.m., bright sun at top of tower.

November 18th, 9 a.m. 4 ft. 29°·0; 170 ft. 32°·4; 260 ft. 34°·6.—11 a.m. 4 ft. 34°·0: 260 ft. 35°·5. Fog at 9 a.m., bright at top of tower.

December 12th, 9 a.m. 4 ft. 26°·5; 170 ft. 26°·2; 260 ft. 33°·2. Dense fog.

Hourly readings throughout the day and night were taken on twelve occasions, and show some very interesting features. The readings are given in Table IV. (p. 278). The following are the observer's remarks on the weather for each occasion:—

1882.—Nov. 11-12.	Fine clear cold night, followed by a fine day with slight fog.
Nov. 18-19.	Dull, wet and squally.
Nov. 25-26.	Fine bright night, dull day, rather windy.
Dec. 2-3.	Snow at night, wet and dull day, fog in afternoon.
Dec. 9-10.	Dull and cold.
Dec. 16-17.	Dull and damp.
Dec. 23-24.	Fine and bright night, slight fog 5-9 p.m.
Dec. 30-31.	Cloudy night, wet day with fog.
1883.—Jan. 6-7.	Fog during night, dull day.
Jan. 13-14.	Overcast. Strong East to South-east wind.
1885.—Sept. 21.	Very fine day.
Dec. 12-13.	Thaw, dull.

The instruments were removed from Boston on June 21st, 1886, and taken to Lincoln, where, by permission of the Dean and Chapter, the electrical thermometer was mounted on the great Tower of the Cathedral. A Stevenson screen containing a set of thermometers was also placed in a garden a short distance from the Cathedral, all the observations being in charge of Mr. H. Mantle, F.R.Met.Soc.

TABLE IV.—HOURLY TEMPERATURES AT 4 FEET AND 260 FEET—CHURCHYARD AND TOWER.

Date.	7 p.m.			8 p.m.			9 p.m.			10 p.m.			11 p.m.			Midnight.			1 a.m.		
	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.
1882.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Nov. 11–12	..	..	..	..	..	..	35·2	38·7	+3·5	34·8	36·6	+1·8	30·9	36·5	+5·6	30·5	37·3	+6·8	31·0	37·4	+6·4
18–19	..	..	..	..	..	..	37·2	35·3	—1·9	37·2	34·9	—2·3	37·2	36·1	—1·1	38·2	37·4	—0·8	38·6	38·0	—0·6
25–26	..	..	..	..	..	..	40·3	38·4	—1·9	39·3	38·4	—0·9	39·3	38·6	—0·7	38·4	38·4	—0·0	38·3	38·0	—0·3
Dec. 2–3	..	..	..	33·3	31·1	—2·2	34·1	31·9	—2·2	34·9	33·2	—1·7	34·3	33·3	—1·0	35·2	32·7	—2·5	34·0	32·3	—1·7
9–10	35·1	34·5	—0·6	35·1	34·2	—0·9	34·6	33·7	—0·9	35·0	34·1	—0·9	34·1	34·1	0·0	34·1	34·1	0·0	33·6	32·9	—0·7
16–17	42·8	41·6	—1·2	42·9	41·9	—1·0	42·8	41·0	—1·8	42·5	41·8	—0·7	43·1	42·5	—0·6	43·2	42·5	—0·7	43·3	42·5	—0·8
23–24	37·2	37·4	+0·2	35·8	35·8	0·0	31·3	32·9	+1·6	33·2	34·9	+1·7	33·2	34·9	+1·7	32·9	34·6	+1·7	32·1	34·0	+1·9
30–31	39·2	39·1	—0·1	38·4	36·7	—1·7	38·5	37·1	—1·4	38·6	36·7	—1·9	38·2	37·4	—0·8	38·2	37·4	—0·8	38·5	38·0	—0·5
1883.																					
Jan. 6–7	39·7	40·3	+0·6	40·3	39·9	—0·4	40·4	40·0	—0·4	38·2	41·2	+3·0	35·5	40·3	+4·8	36·9	39·3	+2·4	37·1	38·7	+1·6
13–14	..	..	..	38·6	37·5	—1·3	38·4	37·9	—0·5	37·8	36·7	—1·1	37·8	36·7	—1·1	37·7	36·7	—1·0	37·5	36·7	—0·8
1885.																					
Sept. 21–22	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Dec. 12–13	..	..	..	..	..	..	37·7	36·0	—1·7	..	..	..	36·9	35·9	—1·0	..	..	..	37·2	37·0	—0·2

Date.	2 a.m.			3 a.m.			4 a.m.			5 a.m.			6 a.m.			7 a.m.			8 a.m.		
	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.
1882.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Nov. 12	33·3	37·4	+4·1	33·0	38·0	+5·0	31·1	35·8	+4·7	30·7	35·0	+4·3	31·1	34·2	+3·1	30·3	34·2	+3·9	30·1	33·6	+3·5
19	39·1	39·9	+0·8	40·7	40·7	0·0	42·3	43·1	+0·8	42·3	42·3	0·0	42·3	42·3	0·0	38·2	39·9	+1·7	38·4	39·9	+1·5
26	38·2	38·0	—0·2	39·1	38·0	—1·1	39·3	39·9	+0·6	40·3	39·9	—0·4	40·2	39·7	—0·5	40·2	39·9	—0·3	40·3	39·8	—0·5
Dec. 3	34·0	32·3	—1·7	34·0	32·3	—1·7	34·1	32·9	—1·2	35·0	34·5	—0·5	35·5	34·7	—0·8	35·7	35·1	—0·6	36·5	35·5	—1·0
10	33·3	33·3	0·0	33·3	33·3	—5·0	33·5	33·3	—0·2	33·5	33·5	0·0	33·1	33·5	+0·4	32·7	31·8	—0·9	30·5	31·1	+0·6
17	43·4	42·5	—0·9	43·6	43·1	—0·5	44·3	43·7	—0·6	44·4	43·7	—0·7	44·3	43·7	—0·6	44·3	43·7	—0·6	44·7	43·7	—1·0
24	32·4	34·0	+1·6	32·2	33·8	+1·6	32·1	33·6	+1·5	31·5	33·6	+2·1	31·2	33·6	+2·4	31·2	32·3	+1·1	31·1	32·9	+1·8
31	40·2	38·7	—1·5	40·3	38·7	—1·6	40·3	39·2	—1·1	40·5	39·3	—1·2	40·7	39·3	—1·4	40·9	39·3	—1·6	41·3	39·3	—2·0
1883.																					
Jan. 7	37·2	38·0	+0·8	36·2	36·1	—0·1	35·1	34·9	—0·2	34·1	34·2	+0·1	35·0	36·7	+1·7	34·3	36·7	+2·4	35·1	36·1	+1·0
14	37·2	36·5	—0·7	36·3	36·1	—0·2	36·2	35·5	—0·7	36·1	34·9	—1·2	35·8	34·2	—1·6	35·6	34·2	—1·4	35·4	33·6	—1·8
1885.																					
Sept. 22	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Dec. 13	..	..	..	36·4	36·7	+0·3	..	..	..	37·2	36·5	—0·7	..	..	..	38·6	37·5	—0·9	..	..	..

TABLE IV.—Hourly Temperatures at 4 feet and 260 feet—Churchyard and Tower.—*Continued.*

Date.	9 a.m.			10 a.m.			11 a.m.			Noon.			1 p.m.			2 p.m.			3 p.m.		
	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.
1882.																					
Nov. 12	31·6°	36·0°	+4·4°	33·6°	38·0°	+4·4°	37·2°	41·4°	+4·2°	40·6°	43·7°	+3·1°	43·9°	44·1°	+0·2°	44·9°	43·8°	—1·1°	44·8°	43·7°	—1·1°
19	40·3	38·9	—1·4	40·5	38·3	—2·2	41·3	39·8	—1·5	42·3	40·8	—1·5	40·5	38·9	—1·6	41·1	42·3	+1·2	40·7	40·2	—0·5
26	40·6	39·4	—1·2	42·0	39·7	—2·3	43·2	41·6	—1·6	42·3	40·3	—2·0	42·7	40·0	—2·7	42·5	40·0	—2·5	43·9	42·3	—1·6
Dec. 3	37·4	36·0	—1·4	39·0	37·5	—1·5	40·3	38·7	—1·6	40·9	39·3	—1·6	41·7	42·8	+1·1	42·7	43·2	+0·5	43·5	45·0	+1·5
10	32·5	32·3	—0·2	33·5	32·1	—1·4	34·4	32·3	—2·1	34·1	31·1	—3·0	34·5	32·8	—1·7	34·3	32·5	—1·8	34·1	32·9	—1·2
17	45·3	43·8	—1·5	45·9	44·5	—1·4	46·3	44·7	—1·6	47·3	44·7	—2·6	47·2	45·4	—1·8	47·1	45·1	—2·0	47·1	44·8	—2·3
24	30·3	32·3	+2·0	32·1	32·6	+0·5	33·1	32·7	—0·4	35·7	33·2	—2·5	36·2	35·3	—0·9	35·9	35·3	—0·6	35·6	35·3	—0·3
31	42·5	40·4	—2·1	42·9	41·2	—1·7	44·2	42·5	—1·7	45·3	43·2	—2·1	46·5	44·6	—1·9	47·3	46·3	—1·0	47·5	46·7	—0·8
1883.																					
Jan. 7	35·5	35·5	0·0	36·2	35·3	—0·9	36·6	36·4	—0·2	37·5	36·1	—1·4	38·4	37·1	—1·3	38·4	36·9	—1·5	37·8	35·9	—1·9
14	35·1	32·9	—2·2	35·0	32·6	—2·4	35·1	32·9	—2·2	35·1	32·6	—2·5	35·6	33·5	—2·1	35·8	33·3	—2·5	36·7	34·0	—2·7
1885.																					
Sept. 22	54·2	52·2	—2·0	55·2	52·3	—2·9	56·8	53·3	—3·5	58·2	55·3	—2·9	59·2	55·8	—3·4	60·5	57·0	—3·5	61·6	56·9	—4·7
Dec. 13	40·3	38·2	—2·1	..	..	..	41·2	39·7	—1·5	..	..	..	42·9	40·4	—2·5	..	..	..	41·5	39·8	—1·7

Date.		4 p.m.			5 p.m.			6 p.m.			7 p.m.			8 p.m.			9 p.m.		
		4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.	4 ft.	260 ft.	Diff.
1882.																			
November	12	43·3°	43·3°	0·0°	41·3°	43·6°	+2·3°	40·3°	43·3°	+3·0°	40·1°	41·9°	+1·8°	40·3°	41·8°	+1·5°	38·5°	42·1°	+3·6°
	19	38·2	37·3	—0·9	38·2	37·9	— 0·3	37·7	37·1	—0·6	36·4	36·7	+0·3	36·3	35·5	—0·8	36·1	34·5	—1·6
	26	44·3	42·5	—1·8	43·3	42·5	—0·8	42·3	41·8	—0·5	43·3	42·1	—1·2	43·3	41·9	—1·4	43·2	41·6	—1·6
December	3	43·3	45·5	+2·2	43·5	43·0	—0·3	43·2	42·7	—0·5	43·6	42·9	—0·7	44·0	43·1	—0·9	44·3	43·1	—1·2
	10	34·1	32·1	—2·0	34·0	31·9	—2·1	33·1	31·0	—2·1	32·6	31·0	—1·6	32·3	30·5	—1·8	32·1	31·0	—1·1
	17	44·9	44·7	—0·2	44·5	44·6	+0·1	44·9	43·1	—1·8	44·9	43·1	—1·8	43·8	41·8	—2·0	43·5	41·5	—2·0
	24	34·7	35·3	+0·6	34·3	35·5	+1·2	34·6	33·8	—0·8	34·5	33·3	—1·2	34·7	34·0	—0·7	34·9	34·0	—0·9
	31	47·5	46·2	—1·3	46·9	45·7	—1·2	47·1	44·6	—2·5	46·9	45·0	—1·9	46·7	45·2	—1·5	46·9	45·0	—1·9
1883.																			
January	7	37·7	35·1	—2·6	38·2	36·5	—1·7	37·7	34·5	—3·2	37·4	34·2	—3·2	37·0	33·6	—3·4	..	..	..
	14	36·7	34·0	—2·7	36·0	34·2	—1·8	35·7	34·0	—1·7	35·3	33·6	—1·7	36·0	33·2	—2·8	..	..	..
1885.																			
September	22	60·2	56·9	—3·3	58·5	56·7	—1·8	57·2	55·2	—2·0	..	..	..	..	..	..	..	..	..
December	13	..	..	..	41·3	39·6	—1·7	..	..	..	40·9	39·3	—1·6	..	..	..	42·2	40·0	—2·2

DISCUSSION.

Mr. Symons said that the Society was greatly indebted to the late Sir C. W. Siemens for the gift of his costly apparatus, without which it would have been impossible to have carried on these observations, and also to Mr. Marriott for preparing this account of the observations. The first series of observations ever carried out (those conducted by Mr. James Six about 100 years ago) were made on one of the towers of Canterbury Cathedral. Observations had also been made at the Pagoda in Kew Gardens, and (very bad ones) at the Radcliffe Observatory, Oxford. The Boston observations were, however, superior to all previously made. The object of the Council in transferring the instruments to Lincoln was to obtain results from a differently situated place. The base of Boston Church was only a few feet above sea-level and the country round was very flat, while Lincoln Cathedral was situated on a hill, and was thus free from the ground fogs which so frequently occurred at Boston. The results of these observations show that the higher we go the less diurnal range we get, a result similar to that obtained in descending below the earth's surface.

Capt. Toynbee inquired whether Sir C. W. Siemens' electrical thermometer had been tested with an ordinary thermometer throughout the observations, and wished to know how it had worked?

Mr. **Symons** stated that the Rev. F. W. Stow, who was regarded as a good critic in the exposure of meteorological instruments, had visited Boston and made an inspection of the situation of the instruments, and had expressed himself as being very well satisfied with their arrangement and exposure.

The President (Mr. Ellis) said that he endorsed all that had fallen from Mr. Symons in regard to Mr. Marriott, who had undertaken the preparation of the paper at the request of the Council at very short notice, and had given an excellent exposition of the whole matter. The diurnal range of temperature diminishes with increase of altitude above the ground, and these Boston and Lincoln observations organised by this Society will, no doubt, tend to improve our knowledge of this question.

Mr. **Marriott** said that the electrical thermometer was compared with the standard instruments at Kew Observatory before being sent to Boston, and Mr. Whipple's report was that it worked very satisfactorily but was a little sluggish. An ordinary thermometer was placed in a wall-screen at the top of the Boston Church tower in close proximity to the electrical thermometer, and comparative readings were made whenever the observer ascended to the top to empty the rain-gauge, which was always done on the first morning of the month, and sometimes on two or three occasions during the month. These occasional comparative readings invariably agreed very well, and proved that the electrical instrument was working satisfactorily. During the whole time that the observations were carried on there was only one occasion when for two or three consecutive days the instrument by some means gave wrong indications, but it eventually righted itself. The gentleman (Mr. Mantle) who had charge of the observations now being carried on at Lincoln Cathedral reported that the electrical thermometer was working very satisfactorily.

SNOW STORM OF MARCH 14th and 15th, 1887, At Shirenewton Hall, Chepstow.

BY E. J. LOWE, F.R.S., F.R.MET.SOC.

[Read May 18th, 1887.]

THE following is a record of the principal features of the great snow storm:—The direction of the wind was North-east, almost calm, and there was no drifting. The oldest inhabitants say they never remember so deep a snow, though there was a deep snow on March 12th, 1867.

The depth here was 20 ins., at Chepstow 20 ins., Piercefield Park 18 ins., Gaerlwydd (Newchurch) 20 ins., near Clevedon 22 ins., Dennil Hill and Tutshill 16 ins., Bristol 16 ins., and at Bath 14 ins. It appears not to have extended beyond Worcester on the one side, or Swindon on the other. It was deep at Newport and Cardiff, and on the opposite side of the Bristol Channel in Somersetshire, descending to the shores of the Bristol Channel, where it remained for several days, an unusual circumstance.

The snow fell at a temperature between 29°·3 and 30°·3, and fell more like dust than snow. Snow commenced falling at 1 p.m., and by 4 p.m. was half-an-inch deep on the ground, and though it continued all the evening not above an inch covered the ground. The greatest fall commenced at 4 a.m. (15th).

The depth at	6 a.m.	was	5 ins.		
„ „	8 a.m.	„	12 „		
„ „	10 a.m.	„	17 „	Amount of water	1·785 in.
„ „	4 p.m.	„	19½ „	„ „	0·283 „
„ „	5.30 p.m.	„	20 „		
„ „	9 p.m.	„	19½ „	„ „	0·130 „

The snow	up to 4 p.m. of 14th	was equal to	12½	ins. to 1 in. of water.
„	from 4 p.m. to 10 a m.	„	9¾	„ „
„	from 10 a.m. to 4 p.m.	„	15	„ „
„	from 4 p.m. to 9 p.m.	„	23	„ „

Where the snow was cleared at 10 a.m. there were 7½ ins. deep of snow at 9 p.m., though this only increased the general depth 3 ins.

The snow was so dry that a severe frost on the night of the 15th did not alter the softness of the surface.

There was no thaw except in sunshine for several days, and the difference between the dry and wet bulb thermometers was great.

The sinking of the snow was as follows:—

16th.	10 a.m.	reduced to	16 ins.	18th.	4 p.m.	reduced to	5½ ins.
	1 p.m.	„	14 „	19th.	10 a.m.	„	5½ „
	5 p.m.	„	12 „		4 p m.	„	5 „
17th.	10 a.m.	„	10 „	20th.	4 p.m.	„	4 „
	1 p.m.	„	9 „	21st.	10 a.m.	„	3¾ „
18th.	10 a.m.	„	7½ „		6 p.m.	„	3 „
	1 p.m.	„	7 „		10 a.m.[1]	„	1½ „

Snow was piled up to the height of 16 ins. on the branches of the trees, and much of it remained up to 10 a.m. on the 22nd, when in an hour it all slid off the branches, and by 10 a.m. on the 23rd the snow had disappeared everywhere.

Only 1·129 in. of rain fell in February, and of this 0·803 in. fell on the first four days. From February 4th to March 14th only 0·50 in. of rainfall, but from the 15th to the 25th 3·132 ins. fell.

[1] From 9 p.m. 2½ ins. of snow fell, followed by rain at 6 p.m.

GREATEST COLD.

	At 4 ft.	On Grass.	On Snow.
March 13th and 14th.........	21°·0	19°·0	°
„ 16th.........	19·8	17·8	14·4
„ 17th.........	17·5	17·0	14·0
„ 18th.........	22·3	21·7	
„ 19th.........	23·2	19·3	
„ 20th.........	21·0	17·3	15·0

A rapid thaw *in sunshine* commenced at noon on 16th, and continued for 2¼ hours, causing the air to be completely saturated for a short time.

Date.	Dry Bulb.	Wet Bulb.	Diff.
16th. 10 a.m.	33°·2	31°·6	1°·6
1 p.m.	36·5	36·5	0·0
3.30 p.m.	37·0	33·2	3·8
4.30 „	36·0	32·0	4·0
5.15 „	34·4	31·8	2·6
17th. 10 a.m.	34·5	32·0	2·5
Noon	37·1	32·3	4·8
2 p.m.	38·4	33·5	4·9
3 „	38·7	33·0	5·7
4 „	37·3	32·3	5·0
6.15 „	32·8	30·0	2·8
18th. 10 a.m.	38·6	34·9	3·7
18th. 1 p.m.	42°·6	37°·1	5°·5
2.30 p.m.	44·1	38·3	5·8
3.45 „	41·6	35·4	6·2
4.30 „	40·0	34·5	5·5
19th. 10 a.m.	36·2	33·2	3·0
4 p.m.	37·0	33·2	3·8
4.30 p m.	35·0	32·0	3·0
20th. 10 a.m.	34·4	32·2	2·2
4 p m.	36·8	33·8	3·0
21st. 10 a.m.	35·3	32·7	2·6
1.30 p.m.	38·8	34·1	4·7

Considerable damage has been done to houses from the weight of snow on the roofs; as well as to branches of trees. As soon as the warmth of the sun caused the snow to move, the force was so great on 15 or 20 feet breadth of roof that the spouting along the eaves was in many cases broken off and fell without the snow sliding off.

At 10 a.m. on the 14th the wind was South-west, and the sky almost cloudless.

DISCUSSION.

Mr. C. **HARDING** said that this severe snowstorm was doubtless caused by the subsidiary disturbance which was moving down the Irish Channel at the time. He noticed that Mr. Lowe gave the direction of the wind as North-east during the fall of snow, but he thought that before the snowstorm there must have been a Southerly wind with rain, and it was not until the secondary had passed to the southward that the snowstorm came on.

Dr. **TRIPE** remarked that the driest and lightest snow he had ever seen was that which fell on January 18th, 1881. This snow found its way into railway carriages even when the windows were closed, and in a carriage in which he was travelling at the time there was as much as 2 inches of snow on part of the seat and floor, which, when brushed off, left the seat quite dry. On that occasion the snow that fell on the 18th remained on the morning of the 19th piled up to the extent of nearly 3 inches on the branches of trees, and the smallest twigs being covered presented a beautiful sight.

ON THE
AMOUNT AND DISTRIBUTION OF MONSOON RAINFALL IN CEYLON GENERALLY,

WITH A

FEW REMARKS UPON AND DETAILS OF THE RAINFALL IN DIMBULA, IN THE CENTRAL PROVINCE OF THAT ISLAND.

BY FRANCIS J. WARING, M.Inst.C.E.

(Communicated by J. W. TRIPE, M.D., Secretary.)

[Read June 15th, 1887.]

SECTION No. 1.

On the Distribution and Amount of Monsoon Rainfall in Ceylon generally.

THE Island of Ceylon, at the southern end of the Indian Peninsula, is situate between the Arabian Sea and the Bay of Bengal, and lies between the parallels of North Latitude 5°58′ and 9°51′, and in Longitude E. of Greenwich 79°42′ to 81°55′. The extreme length of the Island, from Point Pedro in the North to Dondra Head in the South, is 267 miles, while its extreme breadth is 140 miles, the area being 24,702 miles.

Ceylon lies in the track of both the North-east, and South-west Monsoons, and probably receives the full force of the former; but from a study of the Admiralty Chart of the South-west Monsoon, on which the greatest wind force and sea disturbance is shown near Socotra, as well as from the excessive rainfall experienced during that Monsoon on the Western Ghauts in India, it would seem to appear that the central track of the course of the South-west Monsoon generally passes to the North of the Island. The principal feature in Ceylon as determining both the amount and distribution of rainfall is, as will be evident from the annexed maps where its boundary is approximately shown by a dotted line, a group of mountains situate in the South central portion of the Island, equidistant from its East, West, and Southern shores. The coasts of the Island as well as three-fourths of its whole area are flat or only gently undulating, and the monotony of the scenery, especially to the North and East of the mountain zone, is only broken by a few isolated precipitous peaks of gneiss, rising sometimes to the height of several hundred feet above the level country, which is covered with forest or with second growth or scrub, sometimes of great age. The number and height of these isolated peaks decrease as the distance from the mountain zone increases, and North of Vavunia Vilankulam, which is with Anaradhapura about 800 feet above the level of the sea, there exists an unbroken stretch of level forest-covered country extending to the sea coast.

The topography of the mountain zone with its outliers, which, as before stated, appears to play such an important part in the determination of the rainfall of the Island, merits a brief notice.

To the North, East, and South, the exterior face of the mountainous district is very abrupt, and even to the West and South-west, where the country between it and the sea is in places hilly, the line of demarcation between it and the so-called low country is clearly defined.

The average height of the mountains enclosing this zone, which is in shape an irregular circle about 60 miles in diameter, is probably upwards of 4,000 feet; the principal peaks, beginning at the North-west and proceeding by its Western edge to the South and so on, being

Ambokha 4,031 feet, Allagala 3,394 feet, Raksawa 4,774 feet, to the West.
Adam's Peak 7,353 feet, Bena Samanala 6,597 feet, to the South-west.
Etamurawa ... 6,631 feet, Kirigalpota ... 7,832 feet,
The Horton Plains 7,004 feet, Haputale Pass 4,692 feet, to the South.
Namanakuli near Badulla 6,680 feet, to the South-east.
Lunugala 4,431 feet, Galpotuwa 4,710 feet, Haha Eliya 4,511 feet, to the East.

And the circuit is completed by

Medamahanuwara 4,372 feet, The Knuckles 6,115 feet, to the North-east.

The principal, and in fact only gaps worthy of notice in this ring of mountains, are one to the West between Raksawa and Adam's Peak, where the Kelani Ganga formed by the junction of the Kchelgama and Maskeliya Gangas, draining respectively the Dikoya and Maskeliya Valleys, which lie parallel to each other in the South-western portion of the mountain zone, finds an exit through a very narrow and precipitous gorge on its way to its mouth near Colombo. Through another and much wider gap in the North-east of the ring between Haha Eliya and Medamahanuwara, the Mahavilla Ganga escapes. This with its tributaries, the Kotmale Ganga, the Attabage, Maha, Billahul, Kurunda, Uma, Badulla, and Logalla Oyas on its right bank, and the Nanu and Teldeniya Oyas on its left bank, drains fully ⅞ths of the area of the mountain zone, and flowing to the North-east, discharges into the sea near Trincomalee; and finally in the North at Matale, between the Knuckles and Ambokha, the Nalanda Oya, a tributary of the Mahavilla Ganga, which it joins outside the mountain zone, finds an exit.

Internally in the South-west portion of the mountain zone lie two ranges of hills running in a North-west and South-east direction, and therefore at right angles to the direction of both Monsoons, having a general elevation of from 5,000 to 6,000 feet above sea level. These ranges divide the valleys of Maskeliya and Dikoya, and the latter from Dimbula.

The most important internal feature of the mountain zone is, however, a range of mountains which, starting from Kirigalpota in the South, runs in a general North-north-west direction, and therefore nearly at right angles to the Monsoon currents, for 40 miles to a point near Kandy, on the South or right bank of the Mahavilla Ganga, and divides the mountain zone into two nearly equal portions. This ridge reappears to the North of the Mahavilla Ganga, where its culminating point is Hunasgeria Peak, having an elevation of 4,956 feet.

The Southern portion of this central dividing ridge with its spurs includes some of the highest peaks in Ceylon, thus beginning from Kirigalpota, in the South, Totapola 7,746 feet, Hakgala 7,147 feet, Pedro Talagala 8,296 feet, the highest mountain in the Island, False Pedro 6,782 feet, and finally Hantane near Kandy 4,120 feet, are passed on the main ridge; while the Great Western 7,264 feet, and the Peacock 4,975 feet, are spurs on its Western side; and Narangala 5,006 feet, Gommale 5,516 feet, Mahakudagala 6,900 feet, Diyatalawa 5,026 feet, are the culminating points of some of its spurs on the Eastern side.

It will hereafter be seen how great an influence this lofty central range has in the distribution of the rainfall within the mountain zone.

About 20 miles to the South of this central mountain zone, and separated therefrom by a gap not exceeding 400 feet in elevation above the sea, lies a small group of hills comprising portions of the Murawak and Colonna Korles, the culminating point being Gongala 4,445 feet above sea level.

Nearly the whole of the Western half of the mountain zone was till within the last 50 years covered with forest, but within that period almost all the land having an elevation of less than 5,000 feet has been cleared, and is now under tea and coffee cultivation.

On the Eastern side of the central dividing ridge there was and still is a large area of natural grass land locally termed "patana," but in some of the sheltered valleys there was formerly heavy forest, much of which is now cleared for cultivation as in the Western half. The higher ranges, both in the Eastern and Western halves of the mountain zone above 5,000 feet in elevation, are still forest clad, except where naturally grass land.

With these preliminary remarks, the writer will now proceed to the consideration of his subject, recording, however, in the first place his acknowledgments to the labours of the late Col. A. B. Fyers, R.E., Surveyor-General of Ceylon, who took a great interest in Meteorology and established 15 stations where the rainfall is regularly recorded, and who encouraged the planters and others interested to record and forward monthly returns of the rainfall; the system thus established has been continued by Lieut.-Col. F. C. H. Clarke, R.A., C.M.G., the present Surveyor-General of Ceylon, to whose Administration Report to the Government for 1884 the author is indebted for many of the data from which the following figures have been calculated and the annexed maps prepared.

At the present time, besides the fifteen meteorological stations above mentioned, rainfall returns are furnished to the Surveyor-General with more or less regularity from forty-six estates scattered over the Island. The maximum period over which observations have extended in any case has been 15 years, a period which, if not sufficiently long to enable a correct average return to be ascertained, is at any rate valuable as affording an approximation thereto.

The writer has also to tender his acknowledgments to the successive

Directors of Public Works in Ceylon, who have published the rainfall returns from 66 stations at various points in the Island, as well as to Mr. F. d'A. Vincent, who in an able and exhaustive Report upon Forest Administration in Ceylon, has furnished much valuable information as to the topography, physical features, and meteorology of the Island.

It will thus be observed that the writer's task has been principally to collate and analyse existing data prepared by others, and that he has little original to offer except a few deductions from these data.

The South-west and North-east Monsoons in Ceylon may be said respectively to blow steadily from May to August inclusive, and from November to February inclusive. In March and April, and in September and October, the weather is more or less unsettled, and no regular Monsoon or direction of the air current is usually experienced.

In preparing the annexed tables and maps showing the Monsoon distribution of rainfall, the writer has, however, felt himself justified in including April and September as South-west Monsoon months, that being in them perhaps the usual prevailing direction of the air-currents; and in including March and October as months during which the North-east current has the predominance.

Turning now to Fig. 1 (p. 287), showing the average annual rainfall, it will be observed that over fully half the area of the Island the amount is less than 70 ins., and that it is only in the North-eastern and South-western portions of the mountain zone, and in the country lying between them and the sea-coast, that the average fall exceeds 100 ins.; thus clearly pointing to the great effect naturally produced by the hills in inducing precipitation in both Monsoons.

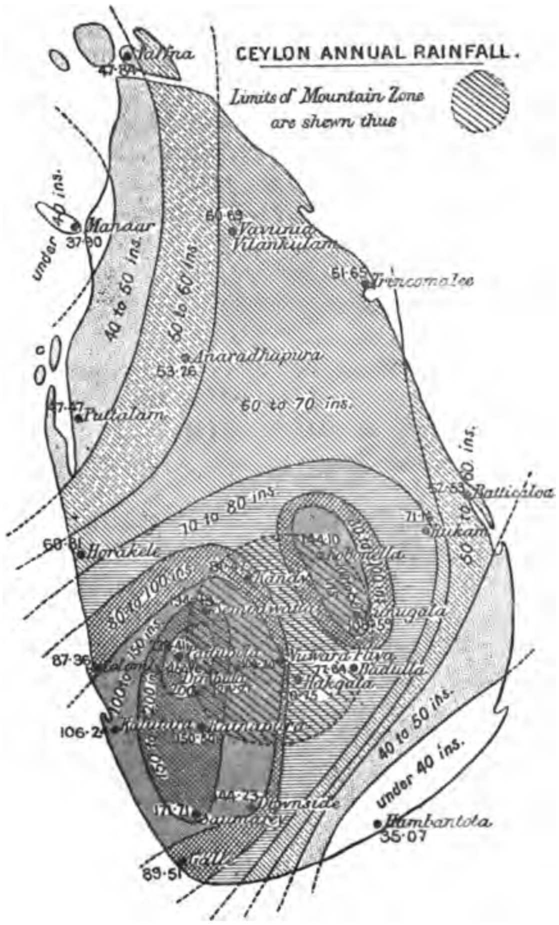
The much larger area of the zone to the South-west of the mountains, in which the fall exceeds 100 ins., as compared with the zone of equal fall lying to the North-east of them, might lead to an exaggerated opinion of the importance of the South-west Monsoon in inducing rainfall over the Island generally, an opinion which will be amply shown hereafter to be most fallacious.

Proceeding in detail, it will be noted that at Jaffna in the extreme north of the Island, lat. 9°40′ N. long. 79°56′ E., the mean fall is 47·84 ins.: proceeding southwards along the coast the fall decreases until at Manaar, in lat. 8°59′ N. long. 79°55′ E., one of the driest spots in Ceylon, it is only 37·90 ins. Southwards of Manaar the fall gradually but slowly increases, and at Puttalam, in lat. 8°2′ N. long. 79°50′ E., the mean annual fall is 47·47 ins. The rate of increase now grows more rapidly: at Horakele estate, near Chilaw, midway between Puttalam and Colombo, it is 60·81 ins., and at the latter place, in lat. 6°56′ N., long. 79°59′ E., it is 87·36 ins.

At Kalutara, 28 miles south of Colombo, the wettest station on the sea-coast of Ceylon, the mean annual fall is 106·24 ins. Southwards of Kalutara the fall decreases, and at Galle, in lat. 6°1′ N. long. 80°14′ E., it is 89·51 ins.

At Galle the direction of the coast-line turns to the East, and the rainfall

FIG. 1.



decreases at an exceedingly rapid rate, until at Hambantota, in lat. 6°7′ N. long. 81°7′ E., the driest station in Ceylon, the mean annual fall is only 35·07 ins.

It is thus singular, though the writer thinks easily explicable, that the two stations experiencing the absolute minimum rainfall in Ceylon should be situate almost exactly opposite to each other at the North-western and South-eastern points of the Island.

Northwards of Hambantota the average annual fall gradually increases, it being 52·53 ins. at Batticaloa in lat. 7°43′ N. long. 81°44′ E., and 61·65 ins. at Trincomalee in lat. 8°4′ N., long. 81°15′ E. Northwards of Trincomalee it gradually decreases until Jaffna is again reached, after a circuit of the Island has been made.

Turning now to the interior of the Island, it will be observed that at

Vavunia Vilankulam, in lat. 8°1′ N., long. 80°38′ E., almost equidistant between Manaar and Trincomalee, the mean annual rainfall is 60·69 ins., almost identical with that of the latter station; and at Anaradhapura, in lat. 8°22′ N. long. 80°23′ E., nearly midway between Puttalam and Trincomalee, and in a line joining them, the average annual fall is 53·26 ins., or nearly a mean between that of those stations.

On the Northern and Eastern face of the mountain ring there is an average annual fall of 144·10 ins. at Kobonella Estate, Medamahanuwara, and 108·59 ins. at Madulsima Hospital, Lunugala; while in the low country to the North-east of the mountains there is an average annual rainfall of 71·14 ins. at Rukam, about 16 miles South-west of Batticaloa.

At Kandy, in lat. 7°18′ N. long. 80°40′ E., in the North of the mountain zone, where the central dividing ridge dies out, admitting the passage of the Mahavilla Ganga River, a mean annual rainfall of 81·22 ins. is experienced.

At Badulla, in lat. 6°59′ N. long. 81°5′ E., to the South-east of the mountain zone and sheltered from the North-east monsoon by the Lunugala and Madulsima hills, the average annual fall is 77·84 ins.

At Hakgala, on the eastern face of but close to the central dividing range, the average fall is 70·75 ins. It is greatly to be regretted that observations at this station extend only over 1½ years, a period much too short to give a trustworthy average, but the marked effect of that ridge in influencing the rainfall is shown by the fact that at Nuwara Eliya, in lat. 6°59′ N. long. 80°47′ E., only 6 miles distant from Hakgala, but on the western face of the ridge, the average annual fall is 100·20 ins. Proceeding towards the western side of the mountain zone the average annual fall increases rapidly, it being 124·27 ins. at Dimbula, 18 miles west of Nuwara Eliya, and 194·13 ins. at Sembawatta Estate, near Nawalapitiya, near the western edge of the zone and about 20 miles South-west of Kandy.

To the South-west and outside of the mountains average annual falls of 171·71 ins. and 144·23 ins. are respectively registered at Saumarez Estate, Udugama, in the low hills, about 15 miles North-north-east of Galle, and at Downside Estate in the Morowak Korale hills.

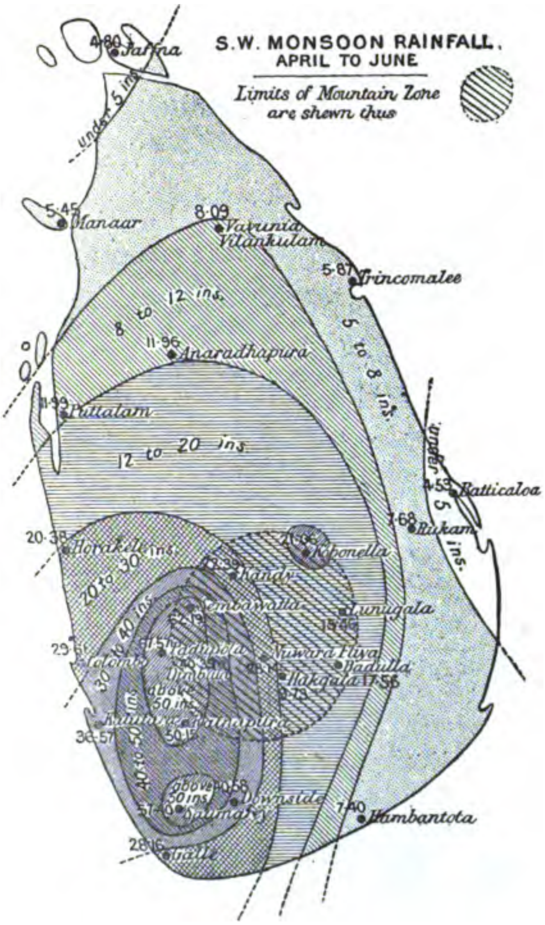
To the West of and outside the mountain zone a mean annual fall of 150·50 ins. is experienced at Ratnapura, in lat. 6°42′ N. long. 80°24′ E., immediately at the foot of Adam's Peak; while to the North of Ratnapura a small district partly within and partly without the mountain zone experiences a mean annual fall of upwards of 200 ins., 228·41 ins. being the average fall at Padupola, about 20 miles from Ratnapura, as recorded by officers of the Public Works Department from observations extending over 13 years.

Fig. 2 (p. 289) shows the distribution and average amount of rainfall during the first half of the South-west Monsoon, viz. from April to June inclusive.

It will be observed that during these three months Jaffna and Batticaloa experience the least fall, the average amounts being 4·80 ins. and 4·53 ins. respectively.

In the North and East of the Island a belt, where the mean fall is from 5

FIG. 2.

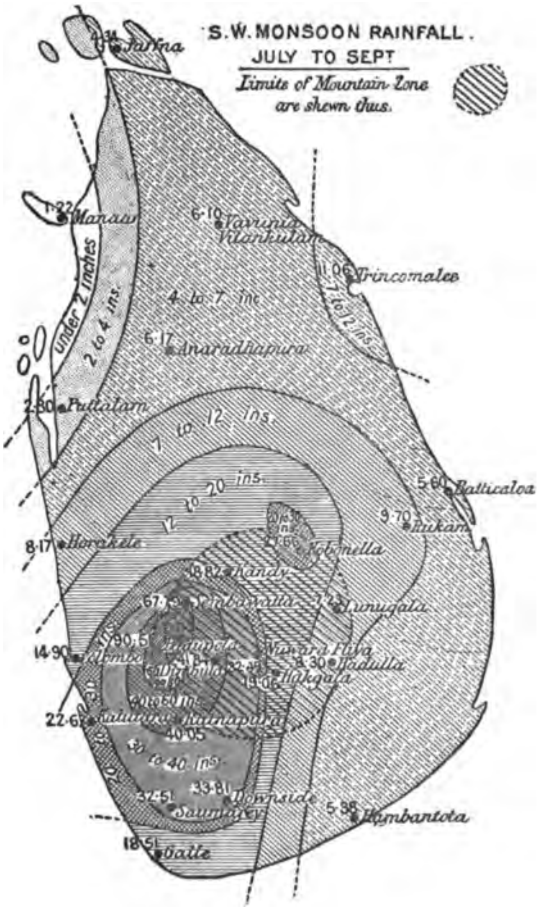


to 8 ins., extends from the South of Manaar to the West of Hambantota, the line of 8 ins. fall passing near Vavunia Vilankulam and Rukam.

Another comparatively narrow belt, especially in the East, where the mean fall varies from 8 to 12 ins., exists, the line of 12 ins. fall passing near Puttalam and Anaradhapura. The flat country to the North of Chilaw and Kandy, and between those places and Puttalam and Anaradhapura, as well as the whole of the mountain zone to the East of the central ridge (except a small district near Kobonella Estate, Medamahanuwara, where the average is 21·06 ins.), receives a mean rainfall of from 12 to 20 ins. In the Western half of the mountain zone the fall is much greater, the means being 22·39 ins. at Kandy, 28·14 ins. at Nuwara Eliya, 40·39 ins. at Dimbula, 62·19 ins. at Sembawatta near Nawalapitiya, while the maximum of 67·57 ins. is recorded at Padupola. At Colombo, Kalutara, and Galle, the average falls respectively are 29·61 ins., 36·57 ins., and 28·16 ins.; at the inland stations of Saumarez Estate and Ratnapura 57·40 ins. and 50·15 ins. are registered, while Downside Estate in Morowak Korale receives a mean fall of 40·58 ins.

In Fig. 3 the distribution and amount of rainfall during the second half of the South-west Monsoon, viz. in the months from July to September inclusive, are shown. This, it will be observed, is over by far the larger portion of the Island the driest quarter of the year.

Fig. 3.



At Manaar the rainfall is practically *nil*, the average fall being only 1·22 in., while at Puttalam, nearly 1° to the South, it is only 2·80 ins.

At Jaffna, Vavunia Vilankulam, Anaradhapura, Batticaloa, and Hambantota, the mean fall is under 7 ins.

At Trincomalee the average fall is 11·06 ins., and much of this is probably due to a few premonitory showers of the North-east Monsoon occurring in

September. To the South of Puttalam the fall rapidly increases, the means being 8·17 ins , 14·90 ins., and 22·67 ins., at Horakele near Chilaw, Colombo, and Kalutara respectively. Southwards of Kalutara a decrease begins, the mean fall at Galle being 18·51 ins.

In the mountain zone a small district in the North-east experiences a heavy fall, 27·66 ins. being the mean at Kobonella, Medamahanuwara. In the rest of the Eastern half of this zone the fall is generally much under 20 ins., being at Badulla and Lunugala only 8·30 ins. and 7·28 ins. respectively. The effect of the central dividing ridge is well marked, the fall being 32·49 ins. at Nuwara Eliya on the Western face, and only 19 ins. at Hakgala on its Eastern face, 6 miles distant.

As the Western boundary of the zone is approached, the fall rapidly increases from 18·82 ins. at Kandy, and 41·84 ins. at Dimbula, to 67·79 ins. at Sembawatta, while the excessive average of 90·51 ins. is recorded at Padupola.

Outside, but to the West of the mountain zone, the mean of 40·05 ins. is recorded at Ratnapura, while Saumarez and Downside Estates receive average falls of 32·51 ins. and 33·81 ins. respectively.

Fig. 4 (p. 292), illustrating the mean distribution and amount of rainfall from October to December inclusive, or during the first half of the North-east Monsoon, shows a remarkable change in the climate as compared with that of the preceding quarter. Over the whole of the Island (except in a limited area near Hambantota, where the average fall is 15·05 ins.) the rainfall is upwards of 20 ins., and indeed over fully three-fourths of its area the mean fall is upwards of 30 ins. Manaar, Puttalam, Chilaw (Horakele), Anaradhapura, and Batticaloa each experience about the same rainfall, the amount varying from 25·29 ins. at Puttalam to 27·50 ins. at Anaradhapura.

At Jaffna, Vavunia Vilankulam, Trincomalee, Rukam, Colombo, Kalutara, and Galle, the mean fall is between 30 and 40 ins.; Vavunia Vilankulam being the wettest of these stations with 37·27 ins. of rain, and Galle the driest with 30·13 ins. Kobonella is during this quarter the wettest station in the Island, the mean fall being 64·11 ins.; Padupola and its neighbour Sembawatta following with mean falls of 55·00 and 53·67 ins. respectively.

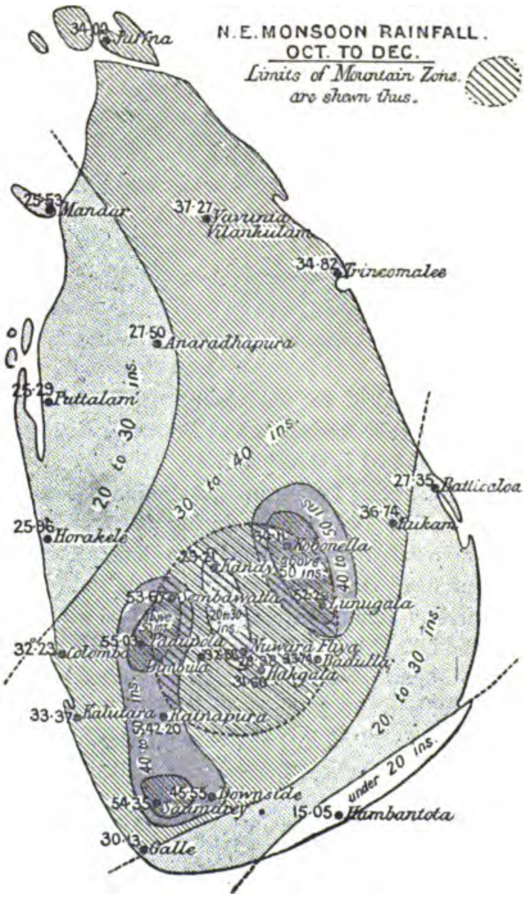
Badulla, Hakgala and Dimbula each receive upwards of 30 ins. of rain in this quarter, while the effect of the central dividing ridge in the mountain zone is shown by Kandy and Nuwara Eliya each experiencing mean falls of less than 30 ins.

Saumarez and Downside Estates have each a wet climate during the quarter, the mean falls respectively being 54·35 and 45·55 ins., while at Ratnapura the fall is 42·20 ins.

Fig. 5 (p. 293) shows the amount and distribution of rainfall during the latter half of the North-east Monsoon, namely, from January to March inclusive.

Batticaloa is during this quarter the wettest sea-coast station in Ceylon, the mean fall being 15·05 ins., decreasing both to the North and South to 9·90 ins. at Trincomalee (which during the preceding quarter was much wetter than Batticaloa), and to 7·24 ins, at Hambantota,

FIG. 4.



The North-western shores of the Island, from Horakele to Jaffna, experience a mean fall of from 4 to 8 ins.

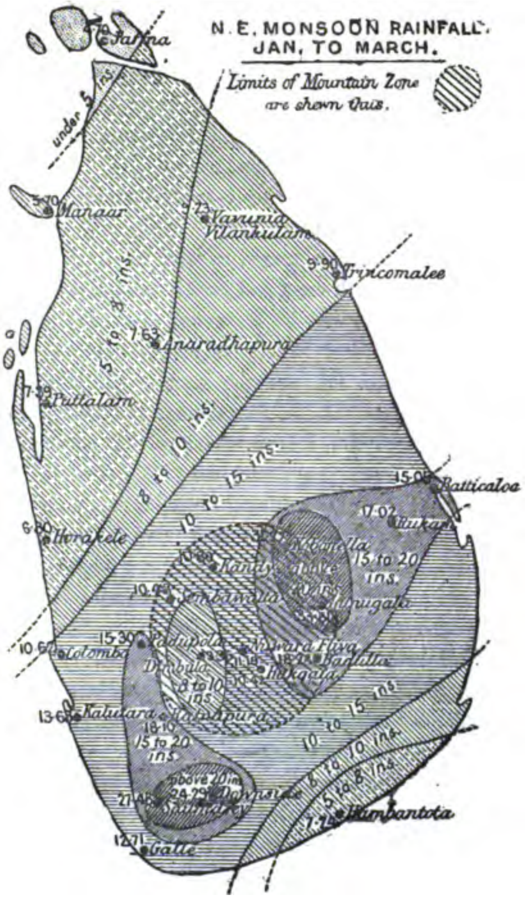
Over nearly the whole of the Southern half of the Island the mean rainfall during the quarter is upwards of 10 ins. with the exception of small areas in the mountain zone to the West of the dividing ridge, where at Dimbula a fall of 9·36 ins. is registered, and near Hambantota, where, as just stated, the fall is only 7·24 ins.

Lunugala is the wettest station in the Island, with an average of 33·61 ins.; Kobonella closely following it with a mean fall of 31·27 ins.

Saumarez and Downside receive falls of upwards of 20 ins., while proceeding Northwards outside the mountain zone the fall decreases to 18·10 ins. at Ratnapura and 15·30 ins. at Padupola.

Having thus briefly glanced at the details of mean amount of rainfall at

Fig. 5.



each station, it remains only for the writer, in conclusion of this part of his subject, to draw a few deductions and to submit a few remarks which he trusts will be amply borne out by examination of the annexed maps and tables.

1st. *The effect of the mountain zone in determining the amount and distribution of rainfall.*—This the writer thinks is very evident from an examination of Map No. 1, where it will be observed that the wettest districts in the Island lie to the North-east and South-west of the mountains, or exactly where their existence, by forcing the moisture-laden currents of air upwards and thus cooling them, induce condensation, and this is also apparent from the, so to speak, negative evidence that both to the North-west and South-east of this zone, or at right-angles to the direction of the prevailing winds, where no hills exist, the rainfall rapidly diminishes to its minima at Manaar and Hambantota.

2. *Apparent gradual veering of the rain-bearing currents of air as each*

Monsoon progresses.—A comparison of Map No. 2 with Map No. 3, and Map No. 4 with Map No. 5, will, the writer thinks, show that as regards the South-west Monsoon, the moisture laden current of air in the early part of that Monsoon approaches the Island from the South-south-west, and gradually veers to the Westward as the Monsoon progresses; while as regards the North-east Monsoon, which appears first to strike the Island from the North-north-east, a gradual veering to the Eastward is similarly apparent during the latter portion of that Monsoon.

3. *Relative insignificance of the South-west Monsoon as compared with the North-east Monsoon in inducing rainfall.*—This will be evident from an inspection of the quarterly rainfall maps, as well as from an examination of the summary of the total North-east and South-west Monsoon falls as given in the Table I., from which it will be observed that out of the total of 25 stations, the details of rainfall of which are given, it is only at 11 of them that the South-west Monsoon fall exceeds that of the North-east Monsoon fall, and that even at Colombo, Galle, Saumarez, and Downside, places at or near the South-west coast of the Island which might be expected to receive the bulk of their rainfall from the South-west Monsoon, this excess is not large. At Kandy the average falls during both Monsoons are almost equal; and it is only stations like Sembawatta and Padupola near the Western boundary of the mountain zone, and Ratnapura completely sheltered by it from the North-east Monsoon, and Dimbula and Nuwara Eliya lying close to but on the Western face of the central dividing ridge, that receive a large excess of their rainfall during the South-west Monsoon.

4. *Cause of the large general rainfall of the North-east Monsoon throughout the Island generally as compared with that of the South-west Monsoon.*—This is probably due to two reasons:—

A. Ceylon lying in the Northern hemisphere, the temperature of the air is less during the winter months, from October to March, than during the rest of the year. This is evident from an inspection of the following table, compiled from returns furnished to the Government by the Surveyor-General.

Station.	Mean Annual Temp.	Mean Temp. from April to Sept., inclusive, SW monsoon months.	Mean Temp. from Oct. to March, inclusive, NE monsoon months.
Colombo	80·7°	81·4°	80°
Ratnapura	79·0	79·6	78·35
Puttalam	80·3	81·6	78·9
Anaradhapura	80·1	82·1	78
Manaar	81·5	83·6	79·8
Jaffna	81·4	83·6	79·45
Trincomalee	80·4	82·4	78·5
Batticaloa	80·6	82·7	78·5
Hambantota	79·9	80·7	79·2
Galle	79·5	80·3	78·8
Kandy	75·4	76·1	74·7
Nuwara Eliya	57·8	58·1	57·5
Badulla	72·1	73·55	70·6
Vavunia Vilankulam	79·7	82·5	76·9

There is possibly no corresponding variation in the temperature of the sea surrounding the Island, and therefore during the North-east Monsoon the rain-bearing current is chilled when passing over the Island, and precipitation is thus induced, while in the South-west Monsoon where no hills occur this cause is absent.

B. Another reason inducing fall during the North-east Monsoon is perhaps found in the fact that the air current in that Monsoon passes over the Island at much slower speed than in the South-west Monsoon. At Puttalam, the mean diurnal velocity of the wind in June is 382 miles, as compared with 117 miles in December. At Jaffna these figures respectively are 332 and 146 miles, at Trincomlee they are 514·7 miles and 305·5 miles, while at Galle they are 228 miles and 70 miles. During the North-east Monsoon therefore the clouds travel but slowly and hang about the country.

5. *Influence of the gaps in the external ring of the mountain zone, and of the central as well as the other ridges in it, in determining the amount of rainfall within the zone, and in the neighbouring districts outside it.*—The gaps in the exterior ring to the West where the Kelani Ganga escapes, and that to the North-east where the Mahavilla Ganga finds an exit, coupled with the break in the central dividing ridge near Kandy, exercise in the opinion of the writer a very considerable effect upon the amount and distribution of the rainfall within the mountain zone.

Thus during the South-west Monsoon the clouds enter the mountainous district at the gap near Padupola, and pass without having been drained of their moisture by being forced upwards by high mountains through the gap in the central ridge near Kandy, until they finally discharge themselves in the mountains near Medamahanuwara and the Knuckles on the North-east side of the mountain ring: this effect is shown upon Maps Nos. 2 and 3, where a small district, of which Kobonella Estate is the centre, possesses from April to September an exceptionally wet climate.

Similarly during the North-east Monsoon the clouds find an entrance at the gap between Haha Eliya and Medamahanuwara, and passing in the opposite direction through the gap in the central ridge near Kandy, doubtless greatly conduce to the exceptionally wet climate of Sembawatta and Padupola, and possibly also the clouds turning to the South outside the ring and clinging to the mountains affect very appreciably the rainfall of Ratnapura.

The ridges dividing the Maskeliya Valley from that of Dikoya, and the latter again from the Dimbula Valley, which with the central dividing ridge are almost parallel and at right angles to the Monsoon currents, have a very important effect in determining the amount and distribution of rainfall within the mountain zone.

Maskeliya, the most westerly of these valleys, has the wettest climate in the South-west Monsoon; this is followed by Dikoya, the next valley; while Dimbula, the third, is drier than the two former, and in it the rainfall gradually decreases as the central dividing ridge is approached. The effect of this dividing ridge is specially marked during the South-west Monsoon,

TABLE I.

Showing the Mean Amount of Annual and Quarterly Rainfall in Ceylon, as registered at 25 Stations, and the corresponding number of days on which rain was registered, and giving also the heaviest Fall recorded in any 24 hours during the period over which Observations have been extended.

Station.	No. of Years' Observations.	Height above Sea-Level.	Average Annual Rainfall.	Average No. of Rainy Days.	SW monsoon.						NE monsoon.						Heaviest Fall recorded in any 24 hours.		Authority.
					April to June.		July to Oct.		Summary.		Oct. to Dec.		Jan. to March.		Summary.				
					Average Rainfall.	Average No. of Rainy Days.	Average Rainfall.	Average No. of Rainy Days.	Average Rainfall.	Average No. of Rainy Days.	Average Rainfall.	Average No. of Rainy Days.	Average Rainfall.	Average No. of Rainy Days.	Average Rainfall.	Average No. of Rainy Days.	Amount.	Date.	
		Ft.	Ins.		Ins.		Ins.		Ins.		Ins.		Ins.		Ins.		Ins.		
Colombo	15	21	87·36	154	29·61	47	14·90	36	44·51	83	32·23	51	10·62	20	42·85	71	11·90	May 4 to 5, 1876	Surveyor-General.
Ratnapura	15	109	150·50	207	50·15	64	40·05	63	90·20	107	42·20	58	18·10	32	60·30	90	11·42	May 8 to 9, 1883	
Puttalam	$14\frac{1}{12}$	11	47·47	70	11·99	17	2·80	5	14·79	22	25·29	35	7·39	13	32·68	48	12·06	May 8 to 9, 1883	
Anaradhapura	$14\frac{7}{12}$	302	53·26	102	11·96	24	6·17	11	18·13	35	27·50	49	7·63	18	35·13	67	6·88	May 8 to 9, 1883	
Manaar	$14\frac{2}{3}$	12	37·90	60	5·45	10	1·22	3	6·67	13	25·53	37	5·70	10	31·23	47	11·00	Oct. 15 to 16, 1884	
Jaffna	14	9	47·84	72	4·80	9	4·34	9	9·14	18	34·00	45	4·70	9	38·70	54	9·92	Oct. 16 to 17, 1884	
Trincomalee	$14\frac{7}{12}$	175	61·65	109	5·87	14	11·06	20	16·93	34	34·82	55	9·90	20	44·72	75	8·21	Jan. 22 to 23, 1878	
Batticaloa	$14\frac{11}{12}$	26	52·53	98	4·53	11	5·60	13	10·13	24	27·35	49	15·05	25	42·40	74	10·46	Jan. 6 to 7, 1878	
Hambantota	15	50	35·07	88	7·40	22	5·38	18	12·78	40	15·05	32	7·24	16	22·29	48	5·05	Dec. 31, '82, to Jan. 1, '83	
Galle	15	48	89·51	200	28·16	57	18·51	58	46·67	115	30·13	54	12·71	31	42·84	85	7·66	Oct. 22 to 23, 1870	
Kandy	15	1696	81·22	190	22·39	49	18·82	60	41·21	109	29·21	58	10·80	23	40·01	81	8·95	May 18 to 19, 1883	
Nuwara Eliya	$14\frac{2}{3}$	6240	100·20	200	28·14	52	32·49	66	60·63	118	28·38	56	11·19	26	39·57	82	9·11	Sept. 9 to 10, 1874	
Hakgala	$1\frac{1}{2}$	5581	70·75	193	9·73	35	19·00	59	28·73	94	31·60	66	10·42	33	42·02	99	4·85	July 12 to 13, 1883	
Badulla	9	2225	77·84	87	17·56	19	8·30	14	25·86	33	33·74	35	18·24	19	51·98	54	9·46	Dec. 12 to 13, 1884	
Vavunia Vilankulam	4	303	60·69	91	8·09	17	6·10	9	14·19	26	37·27	49	9·23	16	46·50	65	9·26	Feb. 4 to 5, 1883	
Horakele Estate, near Chilaw	$14\frac{7}{12}$	50	60·81	95	20·38	29	8·17	18	28·55	47	25·96	37	6·30	11	32·26	48	13·99	July 12 to 13, 1883	
Rukam, near Batticaloa	$14\frac{1}{4}$	120	71·14	84	7·68	12	9·70	12	17·38	24	36·74	38	17·02	22	53·76	60	9·50	Jan. 5 to 6, 1878	
Downside Estate, Morowak Korale	$2\frac{7}{12}$	1767	144·23	241	40·58	63	33·81	74	74·39	137	45·55	58	24·29	46	69·84	104	11·41	May 8 to 9, 1883	
Madulsima Hospital, Lunugala	$4\frac{11}{12}$	3500	108·59	143	15·46	23	7·23	21	22·69	44	52·29	58	33·61	41	85·90	99	6·95	Oct. 26 to 27, 1881	
Kobonella Estate, Medamahanuwara	$2\frac{3}{4}$	3300	144·10	169	21·06	31	27·66	44	48·72	75	64·11	62	31·27	32	95·38	94	4·53	May 8 to 9, 1883	
Sembawatta Estate, Nawalapitiya	$1\frac{11}{12}$	1500	194·13	203	62·19	62	67·79	74	129·98	136	53·67	52	10·48	15	64·15	67	5·50	July 12 to 13, 1883	
Saumarez Estate, Udugama	2	300	171·71	240	57·40	66	32·51	69	89·91	135	54·35	63	27·45	42	81·80	105	4·41	Nov. 22 to 23, and Dec. 21 to 22, 1883	
Padupola	13	1636	228·41	184	67·57	51	90·51	67	158·08	118	55·03	49	15·30	17	70·33	66	18·80	Sept. 8 to 9, 1872	Director of Public Works.
Dimbula	13	4000	124·27	188	40·39	52	41·84	66	82·23	118	32·68	53	9·36	17	42·04	70	9·60	May 8 to 9, 1883	
Kalutara	13	35	106·24	153	36·57	48	22·67	39	59·24	87	33·37	49	13·63	17	47·00	66	8·19	May 14 to 15, 1882	

for to the west of it the districts of Maskeliya, Dikoya, and Dimbula, and even Nuwara Eliya, are for weeks and sometimes for months together enveloped in clouds, and subject to almost constant rain and mist, while at Hakgala, only 6 miles to the east of Nuwara Eliya, but on the other side of the ridge, there is brilliant sunshine and drought only broken by a passing shower.

6. *The cause of the wet climate of Downside and Saumarez Estates* is doubtless due to the position of the hills in which these stations are situate with respect to the mountain zone, which does not shelter them effectually from either the North-east or South-west Monsoons, while the wetter climate of Saumarez as compared with Downside is possibly owing to this group of hills being near the west coast, and to Saumarez lying to the west of Downside and thus receiving more fully the force of the South-west Monsoon.

Section II.

The Rainfall of Dimbula in the Central Province of Ceylon.

The writer having been continuously resident in Dimbula from the beginning of 1880 till August 1886, and having had charge of the construction of a railway passing through that district, has naturally had his attention attracted to the rainfall, especially as regards heavy and unusual falls occurring in that period. Records have been regularly kept by the officers of the Public Works Department from March 1871 till the end of December 1885, with the exception of from April to July 1878 inclusive; to these records the writer has through the courtesy of these officers had access, and it is from them that the annexed results and tables have been obtained and prepared.

Omitting 1871 and 1878, for which years the records are incomplete, it appears the annual fall has varied from 96·36 ins. in 1872 to 160·91 ins. in 1882, the mean annual fall being 124·27 ins.; while the number of days on which rain was registered has varied from 151 days in 1876 to 287 days in 1874, the mean being 188 days.

The average fall per diem throughout the year has thus been $\frac{124{\cdot}27}{365}$ $= {\cdot}34$ in., or reckoning only those days on which rain was registered it has been $\frac{124{\cdot}27}{188} = {\cdot}66$ in.

Table II. shows the number of days in each year, from 1871 to 1885 inclusive, on which rain was registered, the total fall in each year, and also the number of days in each when the fall exceeded 1 inch.

Table III. gives details of some of the heavier falls recorded, whether occurring in one day only or extending over a longer period.

During the first half of the South-west Monsoon, namely from April to June inclusive, the average fall at Dimbula is 40·89 ins. occurring on 52 days; the least falls in this period being 25·58 ins. on 30 days in 1880, and 25·57 ins. on 54 days in 1884; the heaviest fall in this period was in

TABLE II.—Dimbula Rainfall.

Showing Amount of Rainfall in each Year from 1871 to 1885 inclusive, the Number of Days on which Rain was registered, and the Number of Days in each Year in which the Fall exceeded 1 inch.

Year.	Total Rainfall.	No. of Rainy Days.	No. of Days on which the Fall was								
			1 to 2 ins.	2 to 3 ins.	3 to 4 ins.	4 to 5 ins.	5 to 6 ins.	6 to 7 ins.	7 to 8 ins.	8 to 9 ins.	9 to 10 ins.
	Ins.										
1871[1]	128·84	190	27	9	3	2	1	..	..	..	..
1872	96·36	202	16	2	..	2	..	2	..	..	..
1873[2]	59·15	112	17	2	..	..	..	..	..	..	..
1874	134·05	237	31	9	1	..	..	..	..	..	..
1875	102·21	186	27	3	2	..	..	..	..	..	..
1876	107·39	151	26	5	2	1	1	..	..	..	..
1877	152·38	216	31	15	2	..	..	1	..	..	1
1878	129·45	165	35	8	1	1	1	..	..	..	..
1879	145·56	180	42	16	..	2	..	..	..	..	..
1880	126·55	161	32	16	2	..	..	..	..	..	..
1881	135·17	170	35	8	1	..	..	1	..	..	1
1882	160·91	185	38	15	7	1	..	..	..	..	..
1883	110·72	208	26	3	..	1	1	..	..	..	1
1884	100·82	197	26	4	1	..	..	..	..	..	..
1885	114·00	189	25	5	4	..	1	..	..	..	..

[1] For 10 months only. [2] For 8 months only.

1877, when 62·47 ins. of rain fell on 63 days, while 1874 gave the greatest number of wet days, viz. 70.

During the exceptionally wet year of 1882 41·46 ins. of rain were registered in this quarter on 42 days, and during the dry year of 1872 28·69 ins. of rain fell on 53 days.

In the second half of the South-west Monsoon, viz. from July to September inclusive, the mean rainfall is 41·84 ins. falling on 66 days. The least fall registered was 27·15 ins. on 48 days in 1885, while in 1881 the rainy days were fewest, viz. 45, on which 40·62 ins. fell. The maximum fall in these 3 months was in the wet year of 1882, when 71·41 ins. of rain fell on 81 days, while 1874 gave the greatest number of wet days, viz. 86, in which 48·25 ins. were registered.

During the dry year of 1872 43·43 ins. fell in 70 days in this quarter.

In the first portion of the North-east Monsoon, from October to December inclusive, the average fall is 32·68 ins. occurring on 53 days; the least fall being 19·84 ins. on 64 days in the dry year of 1872, while the wet days were fewest in 1879, when 29·21 ins. fell on 39 days.

The maximum fall of 52·40 ins. on the greatest number of wet days, namely 78, occurred in 1877, and in the wet year of 1882 37·40 ins. were registered on 48 days.

The latter part of the North-east Monsoon, from January to March inclusive, gives a mean rainfall of 9·36 ins. on 18 days, the least fall of 1·13 in. on 5 days being in 1876.

The greatest fall of 17·51 ins. on the greatest number of days, viz. 28, was in 1880.

TABLE III.—Dimbula Rainfall.

Heavy Falls of Rain from 1871 to 1885, whether occurring on one day or extending over a longer period.

Date.	Duration of Fall.	Amount.
1871.	Dys.	Ins.
March 31st	1	5·00
April 24th	1	4·40
May 14th	1	3·70
June 2nd to 5th, inclusive	4	8·15
July 4th to 6th, inclusive	3	9·35
July 4th, included in above	1	4·90
July 11th	1	3·20
October 16th	1	3·25
1872.		
June 9th	1	6·45
June 12th and 13th	2	6·95
Sept. 8th to 10th, inclusive	3	12·70
Sept. 9th, included in above	1	7·00
1874.		
March 17th and 18th	2	3·57
May 5th and 6th	2	4·65
May 5th, included in above	1	3·36
June 25th to 27th, inclusive	3	6·23
July 23rd to 27th, inclusive	5	7·96
1875.		
June 13th	1	3·60
August 28th and 29th	2	3·57
November 26th	1	3·47
1876.		
May 5th and 6th	2	6·90
May 6th, included in above	1	5·20
June 28th to 30th, inclusive	3	4·71
August 1st	1	4·06
October 28th and 29th	2	3·16
Nov. 8th to 14th, inclusive	7	11·06
Nov. 8th, included in above	1	3·50
1877.		
May 15th to 18th, inclusive	4	20·15
May 17th, included in above	1	9·30
June 3rd to 6th, inclusive	4	8·38
June 26th	1	3·11
Oct. 19th to 21st, inclusive	3	4·50
Nov. 16th to 19th, inclusive	4	6·10
1878.		
June 7th to 10th, inclusive	4	12·00
June 9th, included in above	1	3·11
July 16th to 20th, inclusive	5	16·85
July 16th, included in above	1	5·44
1879.		
May 19th to 29th, inclusive	11	18·51
May 19th, included in above	1	4·11
1879—*Continued.*	Dys.	Ins.
June 19th to 24th, inclusive	6	14·75
June 22nd, included in above	1	4·20
Oct. 27th to 29th, inclusive	3	4·75
1880.		
May 26th to 31st, inclusive	6	11·15
June 1st and 2nd	2	3·88
August 12th	1	3·60
Oct. 24th to 28th, inclusive	5	13·15
Oct. 27th, included in above	1	3·70
Dec. 29th and 30th	2	3·95
1881.		
June 6th	1	9·35
Aug. 18th to 20th, inclusive	3	10·88
Aug. 20th, included in above	1	6·05
1882.		
May 19th and 20th	2	5·00
June 7th	1	3·20
July 24th to Aug. 11th, inclusive	19	35·22
July 29th, included in above	1	3·68
July 30th ,,	1	4·00
July 31st ,,	1	3·48
August 1st ,,	1	3·34
August 9th ,,	1	3·25
October 8th and 9th	2	6·05
Oct. 8th, included in above	1	3·50
November 23rd	1	3·06
1883.		
May 9th	1	9·60
May 28th	1	5·75
July 13th and 14th	2	6·05
July 13th, included in above	1	4·00
1884.		
May 14th and 15th	2	5·77
May 15th, included in above	1	3·50
October 16th and 17th	2	5·20
1885.		
April 3rd to 6th, inclusive	4	5·00
June 24th to July 4th, inclusive	11	24·85
June 30th, included in above	1	5·80
July 2nd ,,	1	3·25
Nov. 11th to 20th, inclusive	10	10·10
Nov. 12th, included in above	1	3·15
December 13th	1	3·12

In the dry year of 1872 the fall was 4·40 ins. on 15 days, and in the wet year of 1882 it was 10·64 ins. on 14 days.

Taking now, finally, each month in succession, January has a mean fall of 2·17 ins. on 6 days, the minimum being in 1877, when 0·18 in. was recorded on 2 days, and the maximum in 1878, when 6·69 ins. fell on 12 days. In 1878 the minimum fall was 0·11 in. in 4 days, but the records for that year being incomplete, it has been omitted in calculating the averages.

February has a mean fall of 2·30 ins. on 4 days. In 1876 and 1878 this month was rainless, and in 1884 only 0·05 in. was registered, while the maximum of 6·18 ins. on 8 days was recorded in 1880.

March has a mean fall of 4·95 ins. on 7 days, the minimum being 0·41 in. on 3 days in 1876, and the maximum 9·70 ins. on 14 days in 1880. In 1871 15·87 ins. were registered in this month, but the records for that year being incomplete, it has been omitted in calculating the averages.

April shows a mean fall of 7·40 ins. on 14 days, the maximum being 14·04 ins. on 14 days in 1885, and the minimum 3·34 ins. on 6 days in 1880.

The average for May is 12·25 ins. on 14 days, the maximum, 27·60 ins. on 19 days, having been registered in 1879, while the minimum of 1·55 in. on 10 days occurred in 1875.

June shows an average of 19·79 ins. on 23 days; the maximum fall, of 30·71 ins. on 27 days, was in 1881, and the minimum of 7·48 ins. on 11 days occurred in 1880. In 1885 rain fell on every day during this month, the total registered being 28·02 ins.

The mean fall for July is 17·22 ins. on 24 days. The maximum, 36·36 ins. on 30 days, was in 1882; and the minimum, 6·28 ins. on 9 days, occurred in 1881. In 1874 rain fell on every day, the total recorded being 22·32 ins.

August has an average fall of 13·25 ins. on 22 days, the maximum and minimum respectively being 26·04 ins. on 30 days in 1882, and 5·29 ins. on 13 days in 1885.

September shows the following results:—Mean, 11·35 ins. on 20 days; maximum, 26·28 ins. on 27 days in 1872; minimum, 4·25 ins. on 13 days in 1885. In 1874 rain fell on every day during the month, the total fall being 17·24 ins.

October has an average fall of 13·03 ins. on 21 days, the maximum and minimum respectively being 22·83 ins. on 28 days in 1880, and 8·94 ins. on 24 days in 1883.

November gives the following results:—Mean fall 11·71 ins. on 17 days; maximum 25·75 ins. on 30 days in 1877; minimum 5·45 ins. on 12 days in 1878.

December has a mean fall of 7·18 ins. on 14 days, the maximum and minimum being 15·93 ins. on 26 days in 1881, and 3·14 ins. on 10 days in 1872.

DISCUSSION.

Mr. SYMONS said that he had for a long time past received monthly rainfall reports from Ceylon, and considered they were a pattern of what rainfall reports should be. From the first the Government authorities of Ceylon had recognised the importance of the regular registration of rainfall. He was rather surprised that Mr. Waring's longest record only extended over fifteen years, as he was under the impression that some longer series of observations existed. The secret of the success of the Ceylon organisation was that the best instruments were supplied. It had been started well, and the publications had been regular, and, so far as he had been able to ascertain, accurate.

Mr. **Abercromby** found it difficult to reconcile the results of Mr. Waring's discussion of the rainfall observations in Ceylon with what was generally reputed regarding the climate of that island. He understood that popularly the dry season on the west coast was considered to be during the prevalence of the North-east monsoon, but the figures given in the paper showed that most rain fell with the North-east monsoon even on the west coast, as at Colombo. In the Ouvah district of Central Ceylon he was told they secured two crops of coffee in a year, and this was said to be accounted for by this district getting enough rain in both seasons to grow the two crops. Doubtless these statements and the statistics given by Mr. Waring were both alike correct, but figures were sometimes very delusive, as they did not show the true characteristics of the weather of a country. If these rainfall statistics had been put into the hands of a stranger, and he had been asked to reconstruct from them a picture of the weather in Ceylon, he could not have seen the favoured nature of the Ouvah district. Statistics can only reflect more or less imperfectly the climate or weather of a country; and though valuable for many engineering purposes, require to be supplemented by verbal descriptions for meteorological studies. Mr. Waring's suggestions showing the effect of the velocity of the wind on the amount of rainfall were very interesting.

Mr. **Waring**, in reply, said he found it difficult to bring the figures contained in his paper into harmony with the reputed climate of the island. He had frequently had statements made to him by planters respecting the severity of the drought or the heaviness of the rainfall, and had been assured that such a season had never before been experienced, but he had generally found these statements were not borne out by the records of past years. He had been told that frequently in Dimbula months elapsed without a drop of rain falling, but the tables he had collated, showed that February was the only month without rain. It would be seen that at Dimbula, and on the western side of the island, the rainfall during the South-west monsoon was double that which falls during the North-east monsoon. These are the planters' districts, and only cover a small portion of the island, and doubtless, conclusions for the climate of the whole island were drawn from the observations made in those districts.

BALL LIGHTNING SEEN DURING A THUNDERSTORM

ON JULY 11th, 1874.

By JOHN W. TRIPE, M.D., F.R.Met.Soc.

[Read June 15th, 1887.]

I have already referred to this occurence at two Meetings of the Society,[1] but as the phenomenon is at least very rare, and, so far as I know, has not been observed before, I think it worthy of being related in greater detail. Before describing the main features of the storm, I propose mentioning the position and surroundings of my house, as it is owing to them that I was enabled to see what occurred. My house is situated on the south side of the Richmond Road, Hackney, and to the north of the London Fields, with a back garden and gate opening on to the Fields, so that there is an open space, due south,

[1] *Quarterly Journal*, Vol. II. p. 431, and Vol. IV. p. 166.

including the garden, of about 600 yards. On the other side of the fields opposite the back of my house, there is a row of two storied houses, with one or two higher, and behind are three or four streets of two storied houses running parallel with this row, and with the Regent's Canal, behind which are other houses. I have therefore an uninterrupted view of the fields and the sky beyond.

On July 11th, 1874, whilst occupying my sitting room, which is at the back of the house and above the level of the wall abutting on the fields, I heard a clap of distant thunder, and noticed the sky to be darkened by clouds. About a quarter to four, I noticed that the sky was covered with dense dark thunder clouds, and heard a loud peal of thunder; the wind rose rapidly, and then occurred a most violent storm of wind, accompanied by a deluge of rain, extremely loud thunder, flashes of sheet and forked lightning, and large hail stones. The crashes of thunder were for a short time the loudest I ever heard, and followed the lightning without any appreciable interval, in fact they were almost continuous for a few minutes. After a short lull, I saw a ball of fire of a pale yellow colour rise behind the houses, on the other side of the fields, apparently from the Regent's Canal. The ball at first rose slowly, apparently about as fast as a cricket ball thrown into the air, rapidly increasing its rate of motion until it reached an elevation of about 30°, when it started off so rapidly as to form a continuous line of light, proceeding at first due east and then to the west, rising all the time; and after describing several zigzags, disappeared in a large black cloud to the west, from which flashes of forked lightning had come. There were two large black clouds near each other, and the ball when it formed the zigzags moved first towards one and then towards the other. In about three minutes another ball ascended, and in about five minutes afterwards a third, both behaving as the first and disappearing in the same cloud; but although the spots from which each rose were in the same line, the position was rather more to the east.

The general features of the storm were described at the time in a local paper, and afterwards in *Symons's Meteorological Magazine*, Vol. IX. p. 98, an epitome of which I append:—

"On Saturday afternoon, shortly before four o'clock, a most violent thunderstorm burst over the North-eastern district of London. Heavy clouds covered the sky at the time, and a terrific display of forked lightning ensued, the flashes being intensely vivid, and following each other in rapid succession. The peals of thunder were very loud and hailstones as big as beans fell, whilst a heavy driving wind beat them along, blowing down branches of trees, breaking windows and green-house sashes. The North London Railway was flooded in some places so as to stop the traffic, the streets were like rivers, in many cases flooding the basements and cellars. The rain fell so rapidly that it was impossible to see across the road, and in the Richmond Road several of the houses on the south side were flooded. At Nos. 286 and 288 (my number is 282) the water rushed from the London Fields under the garden gates into the houses, and flooded the kitchens and breakfast rooms to a depth of five feet. It was past two on Sunday morning before the water was removed, and then only by the Fire Brigade pumping it out. The Lea and the Regent's Canal overflowed their banks, whilst locomotion in the streets was impossible for some time."

It will be noticed that the writer speaks only of flashes of forked lightning, and not of ball lightning, but he could not have seen the balls unless he were living in one of the houses surrounding the Fields. The rain was the heaviest I ever saw, and, judging from what I have measured at other times, must have been at least 2½ ins., as I was compelled to go into the garden during the rain and let off the water by pulling up the trap covers, otherwise my house also would have been flooded. The greatest fall measured was 1·70 ins.

The storm was noted at Greenwich, and lasted from 3.40 to 5.2 p.m., the rain falling at first with extreme violence, accompanied by vivid lightning. During this time twenty-two flashes of brilliant or very brilliant flashes were noted, and several others; whilst between 3.44 and 3.45½ brilliant flashes of lightning every twelve or thirteen seconds with continual thunder were observed. The electricity from 3.40 till 3.44 was positive, from 3.45½ to 3.53 negative, and at 3.54 and 3.56 it was positive. It was at this time, when the electricity quickly changed from negative to positive, that the first ball lightning was seen.

Mr. Ellis has kindly supplied me with the following information from Greenwich.

EXTRACTS FROM THE METEOROLOGICAL OBSERVATIONS AT THE ROYAL OBSERVATORY, GREENWICH, IN REGARD TO THE THUNDERSTORM OF JULY 11TH, 1874.

Distant thunder was heard at intervals between 3 and 3.20 p.m., after which a violent thunderstorm occurred till 5.0. Rain fell at first somewhat gently, but from 3.45 to 4.15 with extreme violence, and afterwards with variable degrees of heaviness till 5.2. Vivid lightning with thunder very frequent throughout. Between 5 and 7 occasional distant thunder was heard, and at times rain fell also. Rain set in at about 7.38, and at 9 was still falling thinly.

SPECIAL OBSERVATIONS.

h. m.	
2.15	Distant thunder in W.
2.20 to 2.50	Frequent but distant thunder in SW and W.
2.57	Very dark. No rain falling.
2.59	Very dark. No rain falling.
3.0	Rain in large drops.
3.1	Occasional distant thunder S.
3.11	Large drops of rain.
3.20	Very dark W and NW. Heavy rain.
3.21	Flash of lightning: thunder in 10 seconds.
3.22½	Flash of lightning: thunder in 17 seconds, continued 6 seconds.
3.24	Rain continues to fall.
3.25	Very dense clouds NW.
3.26	Thunder NW. Rain still falls.
3.27	Lightning N: thunder in 8 seconds, rumbled 10 seconds.
3.30	Very dense Northwards. Distant thunder in N and NE. Still raining slightly.
3.31	Thunder in N.
3.34	Frequent distant rumblings in N.

SPECIAL OBSERVATIONS—*continued.*

h. m.	
3.35	Very dense in N and NE.
3.36	Very dark: large drops of rain.
3.38	Thunder much louder.
3.40	Rain still falls.
3.40½	Brilliant lightning NE. Thunder in 9 seconds. Continued rumbling of thunder in N.
3.42	Lightning: thunder distant in 15 seconds.
3.43½	Brilliant flash N. Thunder in 17 seconds. Continuous rumblings.
3.44	Brilliant flash in NE. Thunder in 12 seconds. Very loud.
	Brilliant flashes of lightning every 12 or 15 seconds. (Continual thunder.)
3.45½	Rain falling in very large drops.
3.47	Flash in N: thunder 7 seconds.
3.48	Brilliant flash NE. Very heavy thunder in 2·5 seconds. Rain falling very heavily.
3.49	Extremely heavy rain. Very frequent flashes of lightning.
3.50	Brilliant flash: thunder in 4 seconds. Very heavy rain.
3.51	Brilliant flash N: thunder 6 seconds. Very heavy rain.
3.52	Brilliant flash NNE: thunder 5 seconds. Very heavy rain.
3.53	Brilliant flash: thunder 8 seconds. Very heavy rain.
3.54	Brilliant flash: thunder 7 seconds. Very heavy rain.
3.56	Extremely heavy rain. Thunder rumbling continually in N.
3.57	Brilliant lightning: thunder in 7 seconds.
3.58	Brilliant lightning: thunder in 5 seconds. Rain still falls heavily.
4.0	Brilliant lightning: thunder in 9 seconds. Rain still falls heavily.
4.10	Rain continues still falling heavily. Thunder (distant) rumbling continually.
4.13	Brilliant flash: thunder in 12 seconds.
4.15	Brilliant flash: thunder in 12 seconds. Rain falling, though not so heavily.
4.18½	Brilliant flash NE: thunder in 10 seconds.
4.20	Brilliant flash N: thunder in 13 seconds.
4.23	Brilliant flash N: thunder in 16 seconds.
4.25	Brilliant flash N: thunder in 9 seconds.
4.27	Very brilliant flash NNW: thunder in 5 seconds.
4.29	Brilliant flash: thunder in 5 seconds.
4,30	Brilliant flash in NW: thunder 7 seconds: lasted 15 seconds.
4.35	Flash in NNE: thunder 6 seconds.
4.37	Flash in N: thunder 7 seconds.

NOTE ON A MANIFESTATION OF ELECTRICITY AT RINGSTEAD BAY, ON THE COAST OF DORSET,

On AUGUST 17th, 1876.

(Communicated by H. S. EATON, M.A., F.R.Met.Soc.)

[Read June 15th, 1887.]

A REMARKABLE display of electricity was witnessed at Ringstead Bay, on the Dorset Coast, on August 17th, 1876, by Mrs. and Miss Warry, of Holwell, near Sherborne.

North and east of the Bay the cliffs and steep declivities of broken ground, so conspicuous in the view from the Esplanade at Weymouth, descend from the Downs as a kind of undercliff. On the western side of the Bay the cliff diminishes, ending near Ringstead Ledges. About half way down the hill the coast-guard path from Whitenose to Osmington Mill runs close by a small sandstone quarry, on the brow of the cliff where the Upper Green Sand is faulted against the Kimmeridge Clay. The clay extends from the quarry to the foot of the hill, and falls sideways rather abruptly to the beach. The grassy, treeless brink of this clay cliff, for a distance of some 200 or 300 yards from the quarry downwards, and over a width of 3 or 4 yards from the edge of the cliff, was the place where the phenomenon was observed, the height above sea-level being probably from 150 to 250 feet. It is not known how much further the display extended along the edge of the cliff up or down the hill.

The weather for some weeks had been hot and dry, and the fields were parched by the drought; but at last a change was evidently approaching. The day was dull, sunless, and very sultry: from an early hour sheet lightning had been flashing frequently in various directions, unaccompanied by thunder. Between 4 and 5 o'clock in the afternoon the above-mentioned ladies, longing for a breeze, strolled to the edge of the cliff some distance below the quarry from a neighbouring cottage. The heat was oppressive; hardly a breath was astir, but faint puffs of sweltering air surged fitfully upwards from the ground. Mrs. Warry's first impression, on gaining the brink of the declivity facing the sea, was that the heat had affected her sight.

Over the crest of the ground, surrounding them on all sides, and extending from a few inches above the surface to 2 or 3 feet overhead, numerous globes of light, the size of billiard balls, were moving independently and vertically up and down, sometimes within a few inches of the observers, but always eluding the grasp; now gliding slowly upwards 2 or 3 feet, and as slowly falling again, resembling in their movements soap bubbles floating in the air. The balls were all aglow, but not dazzling, with a soft, superb iridescence, rich and warm of hue, and each of variable tints, their charming colours heightening the extreme beauty of the scene. The subdued magnificence of this fascinating spectacle is described as baffling description. Their numbers were continually fluctuating; at one time thousands of them apparently enveloped the observers, and a few minutes afterwards the numbers would dwindle to perhaps as few as twenty, but soon they would be swarming again as numerous as ever. Not the slightest noise accompanied this display.

The ladies sauntered up to the quarry and down again several times along the edge of the cliff, viewing the phenomenon for upwards of an hour with vague and increasing apprehension, and returned to the cottage, leaving the display in active operation. How long it continued, and when it began, is unknown.

About 10 p.m. a severe thunderstorm, attended with torrents of rain, came up from the sea; and on the next day, about 5 p.m., a waterspout was seen off Whitenose.

NOTE ON AN APPEARANCE OF LUMINOUS BUBBLES IN THE ATMOSPHERE.

By the Rev. A. BONNEY, M.A.

(Communicated by R. H. Scott, F.R.S., F.R.Met.Soc.)

[Read June 15th, 1887.]

On a day in the month of January 1871, a lady residing at Park Place, Remenham, observed the following phenomenon shortly before noon.

The weather was intensely cold, snow was lying after a fall some days previously. The sky was dull grey, with " rusty " clouds hanging rather low, the sun just showing itself, and the air was perfectly still.

The wall paper and furniture of the room in which the lady was sitting were suddenly flushed with rose colour, which gradually deepened into crimson, passing through bright gold into orange, lilac and deep violet.

It was then seen that from the centre of the level space of snow within view, a group of air bubbles, of the shape and apparent size of the coloured India rubber balls sold in the streets, rose to a considerable height and then began to move up and down within a limited area, and at an equal distance from each other, some ascending others descending.

The appearance lasted about two minutes, at the expiration of which the balls were carried away by a current of wind to the eastward and disappeared.

Another group of balls arose subsequently from the same spot, and the phenomena were precisely reproduced.

It was remarked that the balls assumed in succession the tints which had been observed on the walls of the room.

The appearance was also witnessed by a maid servant, who, on entering the room, at once exclaimed, " Oh, look at those little balls going up and down."

The above particulars were noted down immediately after a conversation with the lady who saw the bubbles, but she had frequently referred to the matter previously. Though rather advanced in years, she is in full possession of her faculties and is rather unusually keen and observant.

DISCUSSION.

Mr. Marriott read the following extracts:—

(1.) Mr. Maxwell Lyte (President of the Society of Public Analysts), at the Science Club, on August 17th, 1881, gave an account of a remarkable thunderstorm a few years before in the Pyrenees. He, with several English friends, were staying at Bagnières de Bigorre, where they fitted up an old barn as a church, there being a clergyman in the party: this was on the side of a mountain looking down a valley of some miles. On Sunday a storm came on while the service was proceeding, but soon the noise of the thunder and hail was so great that they had to stop the service, and he went about to secure the roof, &c. As he was looking out of the window he saw a ball of fire coming up the valley at a comparatively leisurely rate, say ten or twelve miles an hour: he first saw it at three or four miles distance, and it came directly towards him; it appeared about 6 feet diameter, and as it approached the church he threw himself on the ground, knowing what might happen; the ball, however, went over the house and struck a plum tree in the garden behind, which was shattered to atoms. The explosion was something terrific; and on going out they found the garden in a state of utter confusion—peas, beans, potatoes and the earth all stirred up together in one great mess, and everything completely destroyed, the ground being covered with some inches of large hailstones. No person was hurt there; but a short distance up the mountain nine shepherds had taken shelter in a cabin, which was struck and set on fire; four of the men were killed, three died soon after from the effects of the stroke, and the remaining two were maimed for life.

Another time Mr. Lyte was chamois hunting very high up on the mountain when a storm came on below him; the lightning was an almost continuous flashing from cloud to cloud, and very vivid. As night was approaching he was obliged to descend, and as he came to some pointed rocks the electric fluid was escaping from them in bright brushes, so that he very prudently laid his gun on the ground and got into shelter till the storm passed by. It was on this day that so much damage was done to the town of Toulouse by the flood in the River Garonne, and so many lives lost.

Mr. Lyte remarked that hailstorms of a violent character were frequent in this part of France, but that they were localised, insomuch that the insurance companies refused vineyard risks in some districts, and in others graduated the premiums according to the presupposed frequency and violence of the storms. (Communicated by Mr. R. J. Lecky, F.R.Met.Soc.)

(2.) Ball or Globe Lightning. By R. Dines.

"On August 19th, 1886, during a severe thunderstorm the lightning struck a frame house in New Harmony, exhibiting during part of its course, as far as I can judge after careful examination, the rare case of ball lightning. A portion of this lightning passing from the storm-cloud to the earth struck the south-east corner of the building about 10 feet above the ground, and loosened part of the weather boarding. A part then knocked a hole, 2 feet wide horizontally by 6 inches vertically, in the lath and plaster of the south wall, and rose from this to the stair landing (at a turn going to the second story) around the east cornice of the room, and thence disappeared. Another portion broke a hole about 8 to 10 inches in the east plastering of the said landing at 4½ feet above the landing, which is reached from the room by four steps. The family were mostly assembled in this room, and a young lady of intelligence, about fifteen years of age, informs me she saw the ball of fire about the size of a man's head roll down these four steps and along the carpet without scorching it, out at the east door, a distance of 7 feet. In its passage it grazed the foot of the second daughter, and the family physician informed me the great toe was considerably inflamed as if burned; the mother and youngest son were blinded and almost suffocated for several minutes.

"Outside, a post in the east fence, about 17 feet from the door out of which the ball rolled, was reduced from 10 inches square to 3 or 4 inches in diameter. A tree about 1 foot in diameter, 14 feet from the said east door, was slightly barked on the west side, and had remarkable bruises considerably higher up about 2 or 3 inches in diameter. A somewhat smaller tree, 9 feet due south from the first, was entirely stripped of its bark on the north-east side for 7 feet above the ground, leaving countless slivers hanging from that extremity 3 feet down.

"Judging from all the evidence, it seems probable that the following may explain in some measure the phenomena observed:—The storm-cloud approaching from a south-west direction as positive electricity, to meet the negative electricity of the earth, at the east fence post gave off a portion of its force to the south-east corner of the house. These facts I infer from the great explosive force at the fence post and adjoining trees, and the comparatively small damage done inside the house.

"Only a few cases are recorded of ball lightning, such as one by Flammarion, in his *Atmosphere*, p. 440, at Salagnac, France, where a globe of fire descended the chimney of a house, rolled across the kitchen door, out to a pig pen, where it killed the occupant, without setting fire to the straw on which it lay. In another case, mentioned in Brocklesby's *Meteorology*, which occurred in 1809 in David Sutton's house at Newcastle-on-Tyne, the lightning descended the chimney, and several persons saw a globe of fire advance into the middle of the room and then explode.

"I venture a suggestive explanation of the possible cause, in these cases, of this modified form of electricity, while I admit that it would not seem to apply to those cases where the ball is seen on the water. When coming down the soot of the chimney or through the dust of the crumbled plastering, might not a portion of the electricity be so enveloped in a non-conducting medium as to render its motion slower, and its power for injury less until that envelope is partially removed by striking against a good conductor? The suggestion is based on the idea that the ball would be somewhat in the condition of electricity surrounded by non-conducting glass, as in the Leyden jar, not exploding until connection is made between the interior electricity and a good conductor outside." (*American Meteorological Journal*, Vol. III. p. 383.)

(3.) REMARKABLE OPTICAL PHENOMENON. By S. ALEXANDER.

"The following account of a remarkable optical phenomenon was recently related to me by a lady living in this vicinity. She is intelligent and entirely trustworthy. Her statement has been corroborated by others. The occurrence herein related took place from twenty to thirty minutes before sunset in the latter part of June 1885.

"The weather was more than usually fine. The sky was clear, with the exception of a few clouds of the cumulo-nimbus order a few degrees above and to the northward of the sun. Suddenly there appeared a peculiarly weird and hazy condition of the atmosphere. There was an indescribable commingling and general diffusion of all the hues of the rainbow. During this state of things there appeared in the sky, on the earth, and on the trees, innumerable balls of decomposed light, presenting all imaginable colours, and apparently of about the size of a bushel basket. They were uniform in size and appearance.

"This phenomenon was confined to that region of the sky about the sun, extending but a few degrees each side of it. It lasted about twenty minutes, when it disappeared as suddenly as it came." (*American Meteorological Journal*, Vol. III. p. 486.)

(4.) OPTICAL PHENOMENON. By J. S. LLEWELLYN.

"There was observed here an optical phenomenon similar to that noticed in February Journal. June 5th, 1885, at 7 p.m., there was a haziness covering one-third of the sky in the south with a ray projecting to the east. Tornadoes occurred on June 7th in Iowa, Illinois and Missouri. ·

"Again at 5 p.m. (date lost) there was in the entire atmosphere a brownish weird appearance that was not dust. Tornadoes occurred on the same afternoon in Illinois.

"Sixteen hours before the tornado at Brownsville, Missouri, April 18th, 1882, balls of fire were seen quite numerous at a place 80 miles east of the location of the storm." (*American Meteorological Journal*, Vol. III. p. 533.)

Mr. SYMONS, after reading an extract giving an account of a comparatively recent occurrence of ball lightning, said he had worked at the subject of thunderstorms very thoroughly in the years 1857 to 1859, and had collected a number of reports of lightning phenomena which certainly disagreed with all electrical theories as to the extreme rapidity with which lightning travels. He had no doubt that lightning did frequently travel so slowly that its movements could be easily followed by the eye. He remembered seeing Mr. Varley, at one of the Meetings of the Society of Telegraph Engineers,[1] produce globular lightning, of course, on a small scale, but he caused balls of fire to travel along his machine almost as he liked.

Mr. WHIPPLE said he believed that the rate at which electricity travelled depended entirely upon the conductivity of the medium through which it was conveyed. Along telegraph wires the rate of motion was very rapid, the cables less so, whilst in rarefied air the movement was slow.[2] He had seen experiments made in Dr. de la Rue's laboratory in which electrical discharges in rarefied air took the form of discs whose motion was comparatively slow. In 1872 he saw a bright globe appear in broad daylight, which might possibly have been a manifestation of globular electricity, but at the time he thought it was a meteor, and sent an account of what he saw to *Nature*, describing it as "the appearance of a meteor in broad daylight." He had not seen Mr. Varley's experiments, but he had seen descriptions of something similar to ball lightning artificially produced by M. Gaston Planté[1]. The photographs of lightning exhibited, especially those taken at Brighton, seemed to show that the lightning was really a ball of fire.

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[1] *Jour. Soc. Tel. Eng.* Vol. I. p. 336. *et seq.*

[2] *Phil. Trans.* Vol. 169, Part I.

Rev. W. **Clement Ley** said that although he had been a keen observer of lightning and thunderstorms, he had never in the whole of his experience witnessed an occurrence of globular lightning. In 1873, he saw a heavy thunderstorm come on, and the lightning struck an elm tree about 60 yards from his house. Some persons who lived in a cottage rather nearer the spot where the lightning struck than he was, said they saw a ball of fire descend with the flash, that this ball came in at the front door, and after perambulating round the room retired by way of the back door. He, however, saw no signs of this ball accompanying the flash. On another occasion the lightning struck a cow in a shed about 30 yards from his house, and some persons stated that they observed a ball of fire, but although intently watching the flashes of lightning he saw no signs of a ball of fire. He was rather sceptical respecting these appearances of ball or globular lightning, as in spite of close and careful observation he had not seen these appearances which others stated they had seen, and concerning the certainty of similar occurrences of which Mr. Symons was so firmly convinced.

Mr. **Munro** said he remembered taking shelter in a butcher's shop in Regent Street, Lambeth Walk, twenty-seven years ago, during a very heavy thunderstorm, the rainfall being one of the heaviest downpours he ever experienced. While looking out from his position of shelter, he saw a ball of fire, about 2 inches in diameter, thrown into the air from some invisible source, with streamers of fire or light diverging from it, the ball eventually bursting with a loud report. The occurrence made such an impression on his mind that he had never forgotten it.

Mr. **Waring** said an occurrence of globular lightning came under his notice in Ceylon two years ago. Two coolies, sheltering in a hut during a thunderstorm, said they saw a large ball of fire fall to the ground about 40 or 50 yards from where they were stationed. On hearing the account of this phenomenal occurrence from a planter very soon after it took place, he (Mr. Waring) at first believed it must have been an aerolite which had been observed, and accordingly visited the spot where the ball had been seen to fall, and found a large hole in the ground, the earth all around it being scattered in every direction. He set some coolies to work to dig in order to discover the supposed aerolite, but although they went to a considerable depth they found nothing. The vegetation in the vicinity of the hole had a scorched appearance.

Mr. H. **Sowerby Wallis** said he did not remember any descriptions of globular lightning in which more than one ball was said to have been seen, and he could not conceive of the manifestation of so many isolated particles of electricity—if he might so describe them—as were seen in the phenomenon at Ringstead Bay. The balls seen at Remenham he thought were not electrical, but bubbles caused by the escape of air or marsh-gas from under the snow, Remenham being on the Thames and he believed low ground.

Capt. **Thomson** said that St. Elmo's fire, which has been very frequently observed at sea, is a form of globular or ball lightning; and described how, on board the ss. *Buccaneer* during an exceptionally severe tornado off Sierra Leone in April of this year, balls of fire were observed at the mastheads, where they remained for two hours.

Mr. **Eaton** said, five weeks before the phenomenon occurred, he had walked along the coast-guard path, and could testify to the accuracy of the description of the locality. He first heard of this extraordinary appearance about three years ago, but as Mr. Warry had forgotten the date, he had taken no steps to bring it under the notice of the Society. However, Mr. Warry, who enjoyed excellent health, sustained a strong nervous shock from a flash of lightning in the thunderstorm on the evening of the day in question, and was confined to his bed for a fortnight; and the entry by Mr. T. B. Groves, chemist, of Weymouth, of the medical prescription, gave a clue to the precise date, which had been otherwise confirmed, and he had, therefore, communicated the Paper to the Society. Miss Warry, now Mr. Eaton's sister-in-law, was then a girl in her teens, which might perhaps account for her courage in the necessarily futile attempt to grasp the fire balls. The Paper had been drawn up by his brother the Rev. A. E. Eaton, Vicar of Shepton Montague, Somerset.

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[1] *La Nature*, 1884, Vol. II. p. 196.

Capt. **Wilson-Barker**, in a note to the Secretary, said :—" Dr. Tripe's account of the storm is very interesting ; but I am afraid I belong to the ranks of those who doubt that there is really such a thing as ball lightning. Zigzag lightning has frequently been pointed out to me as ball lightning. I regard this as an optical delusion either on my part or on the part of those who pointed it out. Such a thing is so totally opposed to all one knows of electrical action. It may be interesting to note what does take place between highly electrified clouds. As the clouds approach one another sparks pass between them in single zigzag lines, which are never bifurcated, as is so frequently illustrated, the electric spark taking any direction which offers the least resistance to its passage ; as the clouds get closer, the number of sparks increase, so that we have continual flashes of lightning until the clouds coalesce or disperse. If it were possible to see the clouds quite close to one another and yet not touching, we should find a glow between them, though electric sparks would continue to pass, but would be invisible ; and I feel almost certain that the sparks pass from the positive cloud to the negative cloud. I am somewhat doubtful as to whether photographs will give us any correct idea of lightning flashes, as they cannot at present be taken quick enough. Is it possible that the balls of light seen could be masses of incandescent gas produced by the sudden passage of the electricity along certain paths ?"

Mr. W. **Churchill**, in a communication to the Secretary, said :—" I was walking one evening about 8 or 9 o'clock on the slope of a hill in Dorsetshire. I think it was about October or November 1860 I saw a globe of light, white or pale yellow, not dazzlingly bright, pass slowly between me and the higher part of the hill and fall to the ground, but not making any noise. The whole thing suggested a football of fire. Its apparent diameter was nearly that of the moon. I thought I saw part of the rise of the curve as well as the fall. It was probably not more than a quarter of a mile off. Though I lived near, I heard of no damage done. It was not stormy, or I should not have been out for a stroll. It was on a chalk hill which was ploughed in the part where the ball seemed to fall, but down turf where I was."

NOTE ON THE "SPECTRE OF THE BROCKEN," AS SEEN ON THE PEAK OF TENERIFFE.

By G. B. LONGSTAFF, M.A., M.B.

(Communicated by W. Marcet, M.D., F.R.S., F.R.Met.Soc.)

[Read June 15th, 1887.]

The Val de Taoro is bounded on the west by the crags of Mount Tigayga, which rise about 3,000 feet above it. This mountain is a spur of the Peak, running down from the lip of the Cañadas, or old crater, towards the sea. For a considerable distance its northern slope forms a table-land, perhaps half a mile or more wide, sloping evenly and gradually towards the sea, and limited on the east by a cliff, which falls by a succession of crags to the valley or rather plain below. Along the top of this wall of rock, one of the paths to the Peak runs for several miles. On March 8th, 1887, again on the 13th, and also on April 5th, I passed along this path in the afternoon, an hour or two before sunset. The Val de Taoro was on each occasion covered with thin white mist, which did not extend appreciably above the top of the cliff, being probably so limited by currents of air. As we stood near the edge of the precipice looking over the valley, with the setting sun behind us, we saw our shadows projected on the thin mist ; each shadow of course followed every movement of its owner, keeping for example excellent time to a reel, and on one occasion (March 8th) it was so sharp, that when I went through some cuts and guards of the sword exercise the shadow of my walking stick was perfectly clearly defined. I should say that the spectre varied in distinctness on different occasions and at different spots on the same day, the variations being evidently due to the varying density and outline of the surface of the mist. A lady friend saw it again on April 12th, under similar circumstances in the same place, but it was then far less clear. When seen at its best the spectre was surrounded with three complete sets of faintly coloured rings, the head of the figure being in the centre of the system. A blue haze surrounded the head and reached about to the shoulders; the colours followed in the reversed order of the spectrum, green, yellow, orange and red; the first red ring crossed the figure at its middle, then came blue again, and so on the second red ring reaching about to the feet; outside this again a third reversed spectrum, the outside red ring extending about once and a half the height of the figure. Beyond this triple system of coloured rings, at a distance of perhaps 15° from the line connecting the spectator's eye with the head of the shadow, was an arch of white light, broad and faint, like a lunar rainbow, but sufficiently distinct. Each person could see the rings only around his own spectre, or that of a person standing very close to him. It was extremely difficult to judge the apparent height of the spectre, or its distance from the spectator. It was certainly larger than life, perhaps three times as large; its distance might have been two hundred yards; but I regret that I did not pay especial attention to these points.

The best account of the phenomenon that I have seen is in Glaisher's translation of Flammarion's *The Atmosphere;* but there is some confusion in the description of the order of the colours.

DUST-STORMS IN NEW SOUTH WALES.

By H. C. RUSSELL, B.A., F.R.S., F.R.Met.Soc.

[Read June 15th, 1887.]

THERE is a kind of dust-storm, not uncommon in New South Wales, which possesses some characteristics that may be interesting to the Fellows of the Royal Meteorological Society.

These storms visit New South Wales only during the hot season, and seem to come invariably from about West-north-west, and travel certainly for several hundreds of miles in a nearly straight course. The rate of progress varies, but is always great, and at times reaches 60 miles per hour. The velocity of the wind has not yet been measured, no such storm having passed over one of the recording anemometers. The storm cloud can at times be seen several hours in advance, like an approaching thunderstorm, but when the clouds arrive they are found to be dense dust-clouds. So dense in one case were they, that the light of the sun was entirely blotted out for 15 minutes, and persons in the storm said they could not see their hands before them; and so suddenly did it come on, that fowls laid down in the yard and went to sleep without seeking their ordinary roost.

On the surface of the ground such storms are charged with ordinary dust; but if rain comes on, it brings down a brownish red dust of almost impalpable fineness, the colour of which when wet reminds one of the stories of 'blood rains.' In some cases a dry fog has been seen to hang about places for days without indications of a storm, its progress being apparently slow; but the dust deposited by rain from such fogs is in appearance the same as from the others.

I have brought some of the dust in order that Fellows may see it and judge for themselves, and if possible help in tracing its origin, which is at present an open question. Eventually it may turn out to be similar to that described as having fallen in France some years since, and supposed to have come from South America.

I do not wish to convey the idea that such storms are in their intense forms at all common; perhaps, once or twice in a season, they pass over some part of the Colony, and are difficult to trace in the almost unoccupied interior; but I have been able to trace one certainly for 700 miles, and found some reports which seem to prove that it had crossed the overland telegraph line to Port Darwin before it reached our Colony, making the distance some 600 or 700 miles more.

DISCUSSION.

Mr. **Stanley** said he had time only to make a hasty microscopical examination of the dust or deposit collected by Mr. Russell, and had not discovered anything that might be of an exceptional character to the fine, drifting dust of the country. The mineral matter which the deposit contained consisted chiefly of very fine siliceous sand and other hard minerals of ordinary rocks, with some particles of garnet; many magnetic particles were also present (magnetite). The colour of the deposit was mainly due to iron. The organic and vegetable matter comprised pollen grains, some of a species of mallow, the individuals varying from ·005 in. to ·002 in. in diameter. There were also pieces of wood and portions of the cellular tissue of plants, &c. found in ordinary dust. Of the animal matter separated there was the cast skin of an insect, some pieces of hair, and shells of Rhizopods, probably Arcella, and an embryo shell of a mollusc. Although carefully looked for, no traces of volcanic matter were found in the deposit. Four of the most interesting objects had been mounted on slides, so that Fellows could have an opportunity of examining them through the microscope.

Mr. **Symons** thought the most promising feature in Mr. Stanley's remarks was his statement regarding the discovery of seeds and vegetable matter, as that knowledge might be useful in tracking the origin of this red rain.

Mr. **Inwards** inquired what proportion the magnetic particles bore to the whole amount of mineral matter present in the dust, as it seemed to him remarkable that a substance of comparatively rare occurrence on the earth's surface should be so largely present in these dust-clouds.

Mr. **Scott** said that Mr. Stanley's results agreed with the general conclusions previously arrived at in investigating similar rainfalls. He inquired of Mr. Russell whether the dust-storms he had referred to were those known in Sydney as the 'Brickfielders'?

Mr. **Russell** said that to the South of Sydney there was a large tract of dusty bare land, and the 'Brickfielders' were occasioned by the wind blowing over this barren area and bringing with it the dust which there abounded. This dust was totally different from the red dust. The dust-storms he had referred to come from the West-north-west and travel to the East-south-east.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

May 18th, 1887.

Ordinary Meeting.

William Ellis, F.R.A.S., President, in the Chair.

Arthur Sutcliffe Marriott, Manor Lawn, Dewsbury; and
Capt. **Paul Mordovin**, 160 Buckingham Palace Road, S.W.,
were balloted for and duly elected Fellows of the Society.

The following Papers were read, viz.:—

"The so-called 'Brocken Spectres' and the Bows that often accompany them." By Henry Sharpe. (p. 245.)

"RESULTS OF THERMOMETRICAL OBSERVATIONS MADE AT 4 FEET, 170 FEET, AND 260 FEET ABOVE THE GROUND AT BOSTON, LINCOLNSHIRE, 1882-86." By WILLIAM MARRIOTT, F.R.Met.Soc. (p. 272.)

"SNOW STORM OF MARCH 14TH AND 15TH, 1887, AT SHIRENEWTON HALL, NEAR CHEPSTOW." By E. J. LOWE, F.R.S., F.R.Met.Soc. (p. 281.)

During the evening the President made a presentation to Dr. J. W. TRIPE of a Silver Tea and Coffee Service, which had been subscribed for by a number of the Fellows in acknowledgment of the many services which he had rendered to the Society during a period of over thirty years.

In making the presentation the PRESIDENT said:—

"The Fellows will be aware from a circular which they lately received that, following an occasional custom, it was proposed that there should be this Session a Social Gathering of the Fellows of the Royal Meteorological Society. This took place last evening, May 17th, at the Holborn Restaurant. Previously to the Dinner taking place one thoughtful friend suggested that it should be made complimentary to Dr. Tripe, who has acted so many years as one of the Secretaries of the Society; another friend suggested that the opportunity should be taken to show our appreciation of his services by offering him some Testimonial on the occasion. Neither of these projects originated with myself, but I was very pleased to advocate them. Not that the Testimonial scheme required any advocacy, since we were able to tell Dr. Tripe last night it was taken up most cordially; and he, having been consulted as to the form the Testimonial should take, chose a Tea Service. And in order that those who were unable to be present last evening should be made as it were parties to the presentation, it has been brought here for your inspection.

"I should also mention one or two points alluded to in making the presentation as regards Dr. Tripe's service. He joined our Society in 1856; and since the year 1858, with the exception of one year, he has continually held office, having served 3 years as Member of Council, 6 years as Vice-President, 2 years as President, and in all 17 years as Secretary, altogether 28 years of official work. Dr. Tripe has always taken an active part in all schemes for rendering the Society more generally useful. He advocated the establishment of Climatological Stations, at which, with small tax to the observer, valuable information is obtained, and it was a suggestion of his that led to the institution of those Annual Exhibitions which have of late years proved so interesting a feature of the Society's work. He also inaugurated the custom of reading at the General Meeting a Presidential Address, and his interest in the relation of Meteorology to mortality and questions of Health and Disease is well known.

"We all know how constant an attendant Dr. Tripe has been at our Meetings, and all regret the cause that has in later times prevented his being so much with us. We, however, all trust that that cause may disappear, and that we may in the future see him again, in renewed health and strength, more constantly with us. We trust, too, that this Testimonial presented to him last evening may in after times frequently awaken pleasant memories, not only in his own mind, but also in the minds of those who will rejoice with him at the event of last night."

The Testimonial consisted of a Tea and Coffee Service.

The inscription on the Testimonial was:—'Presented to Dr. JOHN WILLIAM TRIPE by his friends in the Royal Meteorological Society in acknowledgment of many services rendered by him to the Society during more than 30 years.—*May* 1887.'

JUNE 15TH, 1887.

Ordinary Meeting.

WILLIAM ELLIS, F.R.A.S., President, in the Chair.

The following Address to Her Majesty the Queen on the Jubilee of Her Accession to the Throne, as approved by the Council, was read and adopted:—

TO THE QUEEN'S MOST EXCELLENT MAJESTY.

Most Gracious Sovereign,

We, Your Majesty's most dutiful and loyal subjects, the President, Council and Fellows of the Royal Meteorological Society, hereby desire to approach and humbly offer to Your Majesty our heartfelt congratulations on the completion of the Fiftieth Year of Your Majesty's most prosperous reign.

In thus addressing Your Majesty we feel that we only express sentiments which all the different classes and races of Your Majesty's subjects throughout the Empire share with us, and which in this Year of Jubilee have prompted them mutually to encourage and foster such closer union as shall consolidate and thereby strengthen the vast Empire over which Your Majesty's sovereignty extends.

That Your Majesty may be long spared to Your Family, to this Nation, and to the Empire, is the devout wish and prayer of Your Majesty's devoted subjects, the President, Council and Fellows of the Royal Meteorological Society.

Given under the Seal of the Society this fifteenth day of June, in the Year of Our Lord one thousand eight hundred and eighty-seven.

WILLIAM ELLIS, *President.*
G. J. SYMONS, } *Secretaries.*
JOHN W. TRIPE, }

The following Papers were read, viz.:—

"AMOUNT AND DISTRIBUTION OF RAINFALL IN CEYLON GENERALLY, WITH REMARKS UPON THE RAINFALL IN DIMBULA." By FRANCIS J. WARING, M.Inst.C.E. (p. 283.)

"BALL LIGHTNING SEEN DURING A THUNDERSTORM ON JULY 11TH, 1874." By JOHN W. TRIPE, M.D., F.R.Met.Soc. (p. 301).

"NOTE ON A MANIFESTATION OF ELECTRICITY AT RINGSTEAD BAY, DORSET ON AUGUST 17TH, 1876." By H. S. EATON, M.A., F.R.Met.Soc. (p. 305.)

"NOTE ON AN APPEARANCE OF LUMINOUS BUBBLES IN THE ATMOSPHERE." By the Rev. A. BONNEY. (p. 306.)

"NOTE OF THE 'SPECTRE OF THE BROCKEN,' AS SEEN ON THE PEAK OF TENERIFFE." By G. M. LONGSTAFF. (p. 310.)

"DUST STORMS IN NEW SOUTH WALES." By H. C. RUSSELL, B.A., F.R.S. (p. 311.)

Mr. R. H. SCOTT, F.R.S., exhibited records of Wind Force exhibited by the Bridled Anemometer at Holyhead on May 20th, 1887.

CORRESPONDENCE AND NOTES.

SHOWER OF FISH IN NEW SOUTH WALES, JANUARY 24TH, 1887.

MR. H. C. RUSSELL, F.R.S., Government Astronomer for New South Wales, has forwarded to the Society some correspondence which he has received respecting a shower of fish. The following extracts from the letters by Mr. G. S. Hay, Telegraph Station, Walgett, to Mr. Russell, will be of interest.

"January 28th.—I have the honour to report for your information that the mailman running between Walgett and Goodooga, *viâ* the Comborah Springs, north-west from here, brought into town a small fish having the appearance of a small bream, about 3 inches long, which he states he found in the wheel track on a sand ridge about 25 miles this side of the Narran river. The place was alive with them. He says that on Monday night, January 24th, there was a terrific storm of rain and wind, and that these fish fell in the shower. The Narran lake is some 20 or more miles from the spot. I may add that the keeper of the Bunghill Tank, a Government watering place on this route, on hearing of the presence of

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